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Formerly Utilized MED/AEC Sites Remedial Action Program

Radiological Survey of the Former Simonds Saw and Steel Co., Lockport, New York

November 1979

Final Report

Prepared for

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PREFACE

This series of reports results from a program initiated in 1974 by the Atomic Energy Commission (AEC) for determination of the condition of sites formerly utilized by the Manhattan Engineer District (MED) and the AEC for work involving the handling of radioactive materials. Since the early 1940's, the control of over 100 sites that were no longer required for nuclear programs has been returned to private industry or the public for unrestricted use. A search of MED and AEC records indicated that for some of these sites, documentation was insufficient to determine whether or not decontamination work done at the time nuclear activities ceased is adequate by current guidelines.

This report contains the results of a radiological survey to determine the current radiological conditions at the former Simonds Saw and Steel Co. site, Lockport, NY.

The report documents the present radiological condition at the Simonds Saw and Steel Co. site within the realm of today's sophisticated instrumentation and the impact on any future area development.

The results of this survey indicate that there are elevated levels of one or more radionuclides in the on-site buildings and environment. Therefore, based on the results of this survey and previous radiological data remedial measures should be considered to preclude any future concern of inadvertent radiation exposure to people.

The work reported in this document was conducted by the following members of the Health and Safety Research Division, Oak Ridge National Laboratory, Oak Ridge, Tenn:

D. L. Anderson
J. E. Burden
D. J. Christian
B. S. Ellis
F. F. Haywood
R. W. Leggett
W. T. Ryan

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RADIOLOGICAL SURVEY OF THE FORMER SIMONDS SAW AND STEEL COMPANY* LOCKPORT, NEW YORK

R. W. Leggett
M. T. Ryan
D. L. Anderson
D. J. Christian
F. F. Haywood
J. Burden
B. S. Ellis

Health and Safety Research Division
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

ABSTRACT

The results of a radiological survey of the former Simonds Saw and Steel Company (current name of this facility is Guterl Special Steel Corporation), Lockport, New York, are presented in this report. During the period 1948-1956, this company handled large quantities of uranium metal and smaller quantities of thorium metal in rolling mill operations. The survey included measurement of residual alpha and beta-gamma radiation levels in the rolling mill building and forging shop; external gamma radiation in the same area; uranium, radium, and thorium in soil samples taken from beneath removable floor plates in the rolling mill area and from other parts of the site; radon and radon daughter concentrations in the rolling mill building; and contamination in drainage paths leading from the buildings and grounds. Elevated concentrations of uranium were found in soil samples taken from beneath the floor plates within 40 ft of the 16-in. rolling mill. Beta-gamma radiation levels were greater than 1 mrad/hr at the locations having the highest concentrations of uranium. External gamma radiation levels were above the background level in a few small isolated areas in the rolling mill building. The 16-in. rolling mill showed elevated alpha and beta contamination levels in several areas.

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INTRODUCTION

At the request of the Department of Energy (then Energy Research and Development Administration), Oak Ridge Operations, a radiological survey was conducted in Lockport, New York, at the former Simonds Saw and Steel Company. This facility is currently owned and operated by the Guterl Special Steel Corporation. During the period 1948 to 1956, this company handled large quantities of uranium metal and smaller quantities of thorium metal in rolling mill operations. Two buildings on the site were involved in these operations (see Buildings A and B in Fig. 1). These two structures are located in a large industrial area (see Fig. 1) which is sparsely populated. At the time of this survey, approximately 450 people were employed on the site, and of these, approximately 50 worked in the buildings which were involved in the uranium and thorium operations. Building A is still used for rolling mill operations on metal, and the portion of Building B that was used for uranium and thorium operations is now a cleaning area and is used for descaling metal sheets and bars. The first of two contracts with Simonds Saw and Steel Company was negotiated with the New York Operations Office of the U.S. Atomic Energy Commission (AEC). Until the termination of this contract in 1952, Simonds processed 500,000 to 600,000 pounds of uranium per month through the 16-in. bar mill. The second contract was a subcontract with National Lead of Ohio (NLO), who was under contract to the AEC to provide feed material to the Hanford production facility in Richland, Washington. Odd lots which would have required extensive mill changes at the NLO facility were sent to Simonds. During the period 1948 through 1952, approximately 312 rolling mill turns*, consisting of 15,000 to 20,000 pounds of material per turn, were made annually. Production decreased to 29 turns in 1952, 56 in 1954, 58 in 1955, and 22 in 1956. Some of the later materials included depleted and 2.5% enriched uranium. Also, about 30,000 to 40,000 pounds of thorium have been processed through Simonds. Over 99% of all of the work performed by

*A rolling mill turn consists of the heating and roll milling of a fixed number of ingots, defined by the capacity of the furnaces.

Simonds was done on the 16-in. rolling mill. (The rolling mills are located in Building A shown in Fig. 1.) Several small lots of material were run through the 10-in. rolling mill, and some 15 or 20 ingots were processed in the hammer forge shop, which is in an adjacent building (Building B in Fig. 1).

A plan view of the 16-in. rolling mill and associated facilities is given in Fig. 2. The numbers correspond to process steps; the uranium flow chart is given in Fig. 3. This flow chart is accurate for 99% of all material processed at Simonds. Ingots or billets of uranium metal were received in boxes or on pallets and placed in area 1. They were uncrated just prior to rolling and were transferred by crane to the weigh station (2). After weighing, the ingots were rolled into the lead furnace (3), which was of a "Ferris wheel" type for submerging and carrying the charge through the lead. After heating, the ingots were brought along a roller table to the 16-in. rolling mill (4). Two of the four mill stands of the 16-in. mill were used to roll the uranium. Ingot size determined whether shearing (5) was necessary during rolling. After rolling, the uranium bars were later quenched (6) and then transferred in bundles by crane to the shipping area (7), where they were placed in tared H beams, weighed (8), and loaded into railroad cars from the shipping dock (9).

Before the existence of the lead furnace a few limited heatings were performed in the steel furnaces (10, 11, 14) shown in Fig. 2. Steel sheets lined these furnaces during use, and all have been relined with refractory brick since the period of uranium processing. The forge shop furnace hearths are replaced every eight months, and the side walls are replaced annually. The 10-in. mill furnace was completely rebuilt in 1957 after the termination of all the uranium processing. The normal lifetime of both the 16-in. and 10-in. mill furnace hearths is 1 to 2 years, and the side wall lifetime is 3 to 5 years.

During all operations from 1948 through 1956, the AEC was responsible for radiological monitoring and safety. Extensive efforts were made to keep working areas clean. All dross (surface residue) from the lead furnace was skimmed and returned to the AEC or NLO. Protective measures included the use of hoods and dust collection equipment over

the 16-in. rolling mill stands and pans in the mill pits to collect material from every working turn. The mill area was vacuumed after every batch of 16 ingots, and the shipping area was vacuumed daily.

Results of a survey conducted in November 1958 revealed that radiation levels were highest in the quench tank area[1] (6 in Fig. 2). This tank was removed, and clean steel plates were placed over the area. Other areas in which elevated radiation levels were found were vacuumed and scrubbed with water and detergent. A second radiation survey was conducted in December 1958 to verify decontamination.[2]

The present survey was undertaken to characterize the existing radiological status of the property. It was conducted by five members of the Health and Safety Research Division of the Oak Ridge National Laboratory (ORNL) on October 9-10 and 16-17, 1976. The survey included:

(1) measurement of external gamma radiation at 1 m above the floor of the 16-in. rolling mill and adjacent areas on a 45-ft square grid and throughout the remainder of the rolling mill building and forging shop;

(2) measurement of beta-gamma radiation on a 15-ft square floor grid covering the area in which uranium metal had been heated, rolled, and cooled; this was done with the floor plates in place and also with selected floor plates removed;

(3) measurement of uranium, radium, and thorium concentrations in the soil under the removable floor plates;

(4) measurement of alpha and beta contamination levels (fixed and transferable) on building and equipment surfaces;

(5) measurement of radon and radon daughter concentrations in air inside the 16-in. rolling mill building;

(6) measurement of contamination of drainage paths from buildings and grounds.

"Contamination," as used in this report, refers to radioactive materials deposited in or on surfaces whether fixed or transferable. Survey meter readings made on surfaces generally indicate the level of fixed contamination, while standard smear techniques are used to determine the levels of transferable contamination.

RADIOLOGICAL SURVEY TECHNIQUES

Measurements of Alpha and Beta Contamination Levels

Alpha and beta contamination levels were measured on the floor at each of the grid points at 15-ft intervals covering the area in which the uranium metal had been heated, rolled, and cooled (Fig. 4). (This area will be referred to throughout the report as the "grid area.") At some grid points, additional direct measurements of alpha and beta contamination were taken underneath the removable steel floor plates (see Figs. 4 and 5). Measurements of fixed and transferable contamination were also taken at other points throughout the rolling mill building and forging shop including walls, elevated support beams, ceilings, and on the 16-in. rolling mill (see Figs. 4 and 5 and Tables 1 and 2).

Fixed alpha contamination levels were measured with alpha scintillation survey meters, which are described in Appendix I. Transferable alpha and beta contamination levels were determined using standard smear techniques. Measurements were made at each of the locations shown in Fig. 7 and at 111 other locations throughout the rolling mill building and forge shop. The smear counters are described in Appendix I.

Measurements of Beta-Gamma Radiation Levels

Beta-gamma dose rates were measured at 1 cm above the surface of the floor at each of the grid points of a 15-ft square grid covering the same area as the alpha contamination survey discussed above (see Fig. 5 and Table 2). These measurements include natural background and were made with Geiger-Mueller (G-M) survey meters described in Appendix I.

Measurements of Radon and Radon Daughter Concentrations in the Rolling Mill Building

For the measurement of instantaneous radon concentrations in the air in the area of the rolling mills, air samples were taken using evacuated 95-ml glass flasks (known as Lucas chambers) coated with a uniform layer of zinc sulfide. Sample counting was delayed for 3 to 4 hr to allow the radon daughters to attain equilibrium. Each chamber

was placed in light-tight contact with a photomultiplier and counted for 1000 sec. A calibration performed at ORNL using a known radon concentration indicated that the detection efficiency for the Lucas-chamber counting system is 2.02 pCi/liter per cpm. The Lucas chamber and photomultiplier tube are shown in Appendix II.

Air samples were also taken in the vicinity of the rolling mills for the measurement of radon daughters. Air was pumped for 5 min at approximately 12 liters/min through a membrane filter with a maximum pore size of 0.4 μ. The filter was counted using an alpha spectrometry technique refined by Kerr.[3] This technique is described in Appendix II.

Measurements of External Gamma Radiation Levels

External gamma radiation levels which include natural background were measured with scintillation survey meters described in Appendix I. Readings were taken at 1 m above the surface at intervals of 30 to 45 ft in the grid area (shown in Fig. 6) and at the locations listed in Table 3. Scintillation survey meter measurements are indicative of the instantaneous exposure rates at the point of measurement.

Measurements of Uranium, Radium, and Thorium Concentrations in Soil

Soil samples were taken from the metal storage area, from beneath the removable floor plates in the grid area (see Fig. 4), and from other locations inside the rolling mill building. Samples were also collected outdoors, within a few feet of the rolling mill building. The samples were packaged in plastic bags before being returned to Oak Ridge, where they were dried for 24 hr at 110°C and then pulverized to a particle size of 35 mesh (500 μm). Next, aliquots from each sample were transferred to plastic bottles, weighed, and counted using a Ge(Li) detector. The spectra obtained were analyzed by computer techniques. A description of the Ge(Li) detector and the soil counting techniques is given in Appendix III. Uranium, radium, and thorium concentrations were determined for all samples (see Table 4). Two samples were analyzed for concentrations of individual uranium isotopes using mass spectrometry techniques (see Table 5).

Measurements of Radioactivity in Surface Water

Water samples were taken from the drainage of the mill building and from a nearby canal which served as the outfall for rolling mill coolant water. In addition, a tap-water sample was taken from the city water system. The samples were analyzed at ORNL using radiochemistry techniques (see Table 6).

SURVEY RESULTS

Results of Soil Sample Analyses

Concentrations of ^{238}U, ^{226}Ra, and ^{232}Th in soil samples collected on the site are listed in Table 4. Locations of outdoor soil samples are indicated in Fig. 2, and grid points referred to in Table 4 can be found in Fig. 4. Three samples taken from the surface beneath the removable floor plates in the area near the 16-in. rolling mill showed concentrations of ^{238}U in excess of 10,000 pCi/g. Samples collected outside the grid area showed ^{238}U concentrations from 1.8 to 62 pCi/g (see Fig. 8). Because some enriched uranium had been processed at this facility, two samples (5F-1 and 11E) were analyzed for the concentrations of individual uranium isotopes ^{234}U, ^{235}U, and ^{238}U. Mass spectrometry techniques were used to provide this information. Results of this analysis (see Table 5) revealed an isotopic ratio equivalent to natural uranium deposits.

Radium-226 concentrations in the 29 soil samples were no higher than 1.1 pCi/g. These low concentrations of ^{226}Ra were to be expected, since there has not been sufficient time for significant ingrowth of ^{226}Ra from the initially pure uranium, and since no uranium ore was processed at Simonds.

The highest concentration of ^{232}Th found in soil samples was 11 pCi/g. Twenty-two of the 25 samples collected inside the building showed ^{232}Th concentrations of less than 3 pCi/g. In most samples, the activity of ^{232}Th was less than 1% of the activity of ^{238}U.

Alpha and Beta Contamination Levels

Direct measurements of alpha contamination levels taken in the 16-in. rolling mill building and in the forging shop are given in Table 1 and Fig. 4. Direct readings of alpha contamination levels taken outside the grid area were in the range of 0-60 dpm/100 cm^2 (see Table 1). Alpha contamination levels in the grid area (but excluding the 16-in. rolling mill itself) were as high as 4600 dpm/100 cm^2 by direct reading, with the highest readings being recorded within 20 ft of the 16-in. rolling mill (see Fig. 4). Most of the contamination in this area was found on or under the floor plates. On the 16-in. rolling mill, direct measurements of alpha contamination were as high as 1500 dpm/100 cm^2, with maximum readings being recorded on the left outside surface of mill B (see Fig. 9). Results of the survey of the 16-in. rolling mill are reported in Table 7. Direct readings of alpha contamination on walls, beams, rafters, and ceilings in the rolling mill area were in the range of 0-60 dpm/100 cm^2. According to guidelines issued by the U.S. Nuclear Regulatory Commission (NRC)[4] for the release of property for unrestricted use, average and maximum acceptable levels* of alpha contamination on surfaces are 5000 dpm/100 cm^2 and 15,000 dpm/100 cm^2, respectively, provided the radioactive contaminant is natural uranium (see Appendix IV). This is also consistent with a proposed (ANSI) standard.[5] The radioactive materials processed on the site were natural uranium and natural thorium, and there has been sufficient time for ^{228}Th to attain almost complete (~80-90%) radioactive equilibrium with ^{232}Th. Furthermore, for surfaces contaminated with ^{228}Th, the NRC average and maximum allowable limits of alpha contamination are 100 dpm/100 cm^2 and 300 dpm/100 cm^2, respectively (Appendix IV). Hence, the standards for ^{228}Th are 50 times more restrictive than those for natural uranium. However, it appears from the relative activities of ^{238}U and ^{232}Th in soil samples from Simonds that the standard for natural uranium is the appropriate standard to be applied to this site. At 14

*Measurements may not be averaged over more than 1 square meter. The maximum contamination level applies to an area of not more than 100 cm^2.

of the points of measurement in the rolling mill building (all 14 in the grid area), alpha radiation was higher than 100 dpm/100 cm^2 by direct reading (see Fig. 4), either on the floor plates or open dirt, or on the soil beneath the removable floor plates. Soil samples were taken from beneath the floor plates at 9 of these 14 locations (see Table 4 and Fig. 4); and in 8 of these 9 soil samples, ^{238}U concentrations were at least 100 times as much as ^{228}Th concentrations (assuming equilibrium of ^{232}Th and ^{228}Th). At location 11E (Fig. 4), where alpha contamination in the open dirt was 310 dpm/100 cm^2 by direct reading, the activity of ^{238}U was about 38 times the activity of ^{228}Th (assuming equilibrium of ^{232}Th and ^{228}Th). Hence, it is reasonable to assume that less than 3% (or 10 dpm/100 cm^2) of the total alpha activity at this location is from ^{228}Th.

Smear samples were taken at the locations given in Fig. 7 and at 111 other locations throughout the rolling mill building and forging shop including walls, beams, rafters, ceilings, and 54 locations on the 16-in. rolling mill. None of the smears showed alpha contamination in excess of 15 dpm/100 cm^2, and all smears showed less than 100 dpm/100 cm^2 of beta contamination. These levels are well within the allowable limits defined by the NRC[4] for surfaces contaminated with natural uranium and its daughters. (Although NRC guidelines[4] for transferable beta contamination levels are 50 times more stringent for ^{228}Ra [a daughter of ^{232}Th] than for natural uranium, it appears by arguments analogous to those concerning ^{228}Th that the guidelines for natural uranium should be applied here.)

Beta-Gamma Radiation Levels

Direct readings of beta-gamma radiation levels are given in Table 2 and Fig. 5. Measurements taken outside the grid area were in the range of 0.01-0.04 mrad/hr (see Table 2), and the measurements on walls, beams, rafters, and ceilings were less than 0.01 mrad/hr. In the grid area (Fig. 5), some readings taken within 40 ft of the 16-in. rolling mill on the floor and on the soil beneath the removable floor plates were above 1.0 mrad/hr. On the 16-in. rolling mill, beta-gamma dose

rates were as high as 3.5 mrad/hr (see Table 7). According to NRC guidelines[4] for unrestricted use, the maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 1.0 mrad/hr. The highest beta-gamma radiation level measured was 42 mrad/hr at a point under a floor plate near the old quench tank area (Fig. 5). A sample of this material (see sample 5F-1, Table 4) was returned to Oak Ridge for determination of uranium, radium, and thorium content. Analysis showed a uranium concentration of 21,000 pCi of U/g soil (6.3%) uranium; no radium or thorium was found in the sample. No significant reduction in the radiation level was noted after removal of the sample.

External Gamma Radiation Levels

Measurements of external gamma radiation levels at 1 m above the floor in the rolling mill building and forging shop are given in Fig. 6 and Table 3. Outside the grid area (see Table 3) the maximum reading was 12 μR/hr, which is within the range of background measurements which have been taken in the Lockport area. In the grid area, readings were as high as 48 μR/hr in an area south of the 16-in. rolling mill and between the 10-in. and 16-in. furnaces (see Fig. 6). This area, which is not covered by floor plates, has been used for storage of mill rollers for several years, including the period of uranium and thorium operations. An area of not more than 5 m^2 is associated with these elevated gamma readings.

Radon and Radon Daughter Measurements in the Rolling Mill Building

Air samples were taken east and west of the rolling mill area for measurement of radon (^{222}Rn) concentrations. Both samples showed radon concentrations of less than 0.4 pCi/liter. Two additional air samples were taken for the measurement of radon daughter concentrations, one approximately 50 m from the main entrance of the rolling mill building and the other in the rolling mill area. Both samples showed radon

daughter concentrations well below 0.001 WL.* These results for radon and radon daughter concentrations are consistent with the fact that only small quantities of radium, the parent of radon, were found in the building.

Results of Water Sample Analyses

Concentrations of ^{238}U, ^{226}Ra, and ^{232}Th in water samples taken on and near the site are listed in Table 6; this table also gives the concentration guides (CG's), commonly referred to as the maximum permissible concentrations (MPC's), for each radionuclide tested. Sample 1 is a tap-water sample taken from the city water system, sample 2 was taken from a nearby canal which served as the outfall for rolling mill coolant water, and sample 3 was taken from the drainage from the mill building. In each sample, the concentration of each radionuclide tested was a factor of 10 or more below the MPC_w.[6]

SUMMARY

The site was used for rolling mill processing of large quantities of uranium metal and relatively small quantities of thorium metal during the period 1948-1956. High concentrations of uranium were found in soil samples taken near the 16-in. rolling mill and at other points in and near the rolling mill building. Samples taken from beneath the removable steel floor plates near the 16-in. roll mill showed ^{238}U concentrations as high as 21,000 pCi/g. It should be noted that the specific activity of ^{238}U is 3.33×10^{-7} Ci ^{238}U/g ^{238}U; therefore, this sample of soil contains:

$$\frac{2.10 \times 10^{-8} \text{ Ci } ^{238}\text{U/g soil}}{3.33 \times 10^{-7} \text{ Ci } ^{238}\text{U/g } ^{238}\text{U}} = 0.063 \text{ g } ^{238}\text{U/g soil.}$$

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*A working level (WL) is defined as any combination of short-lived radon daughters in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of alpha particle energy.

This is equivalent to 6.3% uranium in the soil and exceeds the concentration of 0.05% uranium requiring a source material license.[7] This latter value is equivalent to 172 pCi ^{238}U/g soil. It is seen in Table 4 that 55% of the samples contain uranium in excess of the "source material" level. Concentrations of ^{238}U found in five samples taken from in and around the metal storage area ranged from 5.8 to 50 pCi/g. One soil sample taken from a section of the rolling mill building remote to the uranium operations showed a ^{238}U concentration of 13 pCi/g, and a sample taken outdoors near the south wall of the rolling mill building showed a ^{238}U concentration of 62 pCi/g. The highest concentration of ^{232}Th found in any sample was 11 pCi/g. Normal background concentrations of ^{238}U, ^{226}Ra, and ^{232}Th are approximately 1 pCi/g each, on the average, in the Lockport area.

After 20-28 years, the ingrowth of ^{226}Ra from the natural uranium is negligibly small, but ^{228}Th has had sufficient time to attain 80-90% equilibrium with ^{232}Th. However, the large ratio of ^{238}U activity to ^{232}Th activity in soil samples taken on the site indicate that in applying surface contamination guidelines provided by the NRC, the guidelines for natural uranium should be used. The levels of residual alpha radiation measured on the site are below the NRC guidelines, provided the standards for uranium are applied. However, some direct readings of beta-gamma radiation taken on the floor and underneath the removable floor plates near the 16-in rolling mill exceeded 1 mrad/hr, which is the maximum allowable for unrestricted use according to the NRC guidelines.[4] Transferable alpha and beta radiation levels on the site appear to be low; all smears showed less than 15 dpm/100 cm^2 alpha contamination and less than 100 dpm/100 cm^2 beta contamination.

External gamma radiation levels inside the rolling mill building near the 16-in rolling mill were as high as 48 μR/hr. An individual exposed to this gamma radiation level for 40 hr each week would realize an integrated dose equivalent of approximately 100 mrem/year. However, the areas associated with the high readings were small. In most areas inside the building, external gamma radiation was near background levels.

It appears from the survey results that there is no potential problem from radon and radon daughters in the building. This is supported by the findings of only small traces of ^{226}Ra in samples.

In water samples taken from the drainage from the site, the concentrations of ^{238}U, ^{226}Ra, and ^{232}Th were below the maximum permissible concentrations.[6]

In summary, it appears that most of the radioactive contamination resulting from uranium and thorium operations during the period 1948 to 1956 is confined to the area inside and immediately outside the rolling mill building. Some areas near the 16-in. rolling mill contain uranium in excess of the "source material" level. On the 16-in. rolling mill, alpha and beta-gamma contamination levels (by direct measurement) were found in excess of NRC guidelines.

An evaluation has been made of current radiation exposures at the Guterl Special Steel Corporation site and is presented in Appendix V (page 75) of this report. The purpose of this evaluation is to present information which will permit the reader to compare current radiation exposures from the site to normal background exposures for that part of New York, as well as to scientifically based guideline values established for the protection of radiation workers and members of the general public.

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7. Code of Federal Regulations, Title 10, Part 40, "Licensing of Source Material."

ORNL Photo 2089-77

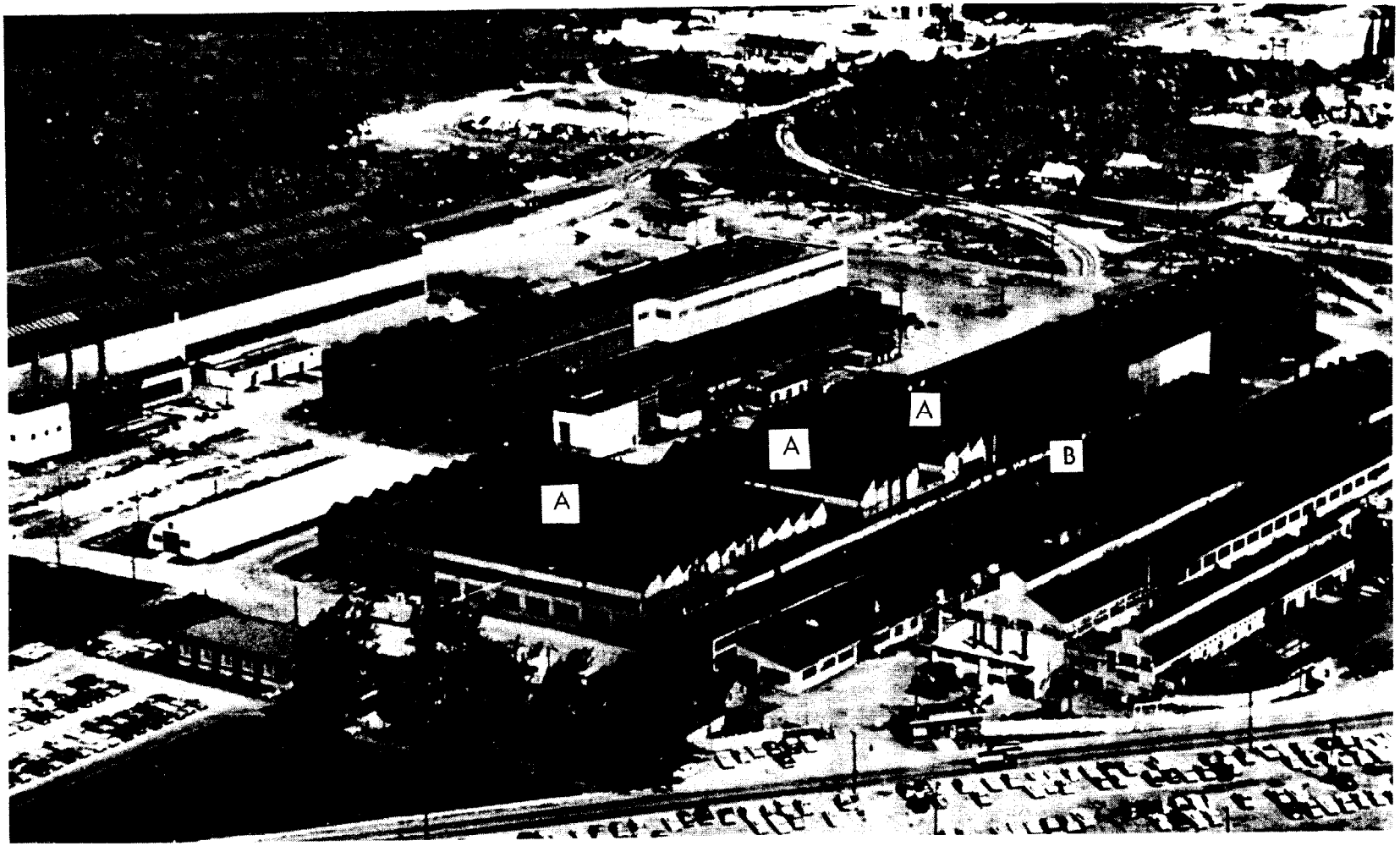

Fig. 1. Aerial photograph of the former Simonds Saw and Steel Company and surrounding area.

Numbers in circles correspond to process steps.
FCE - Furnace.

ORNL DWG 77-5055

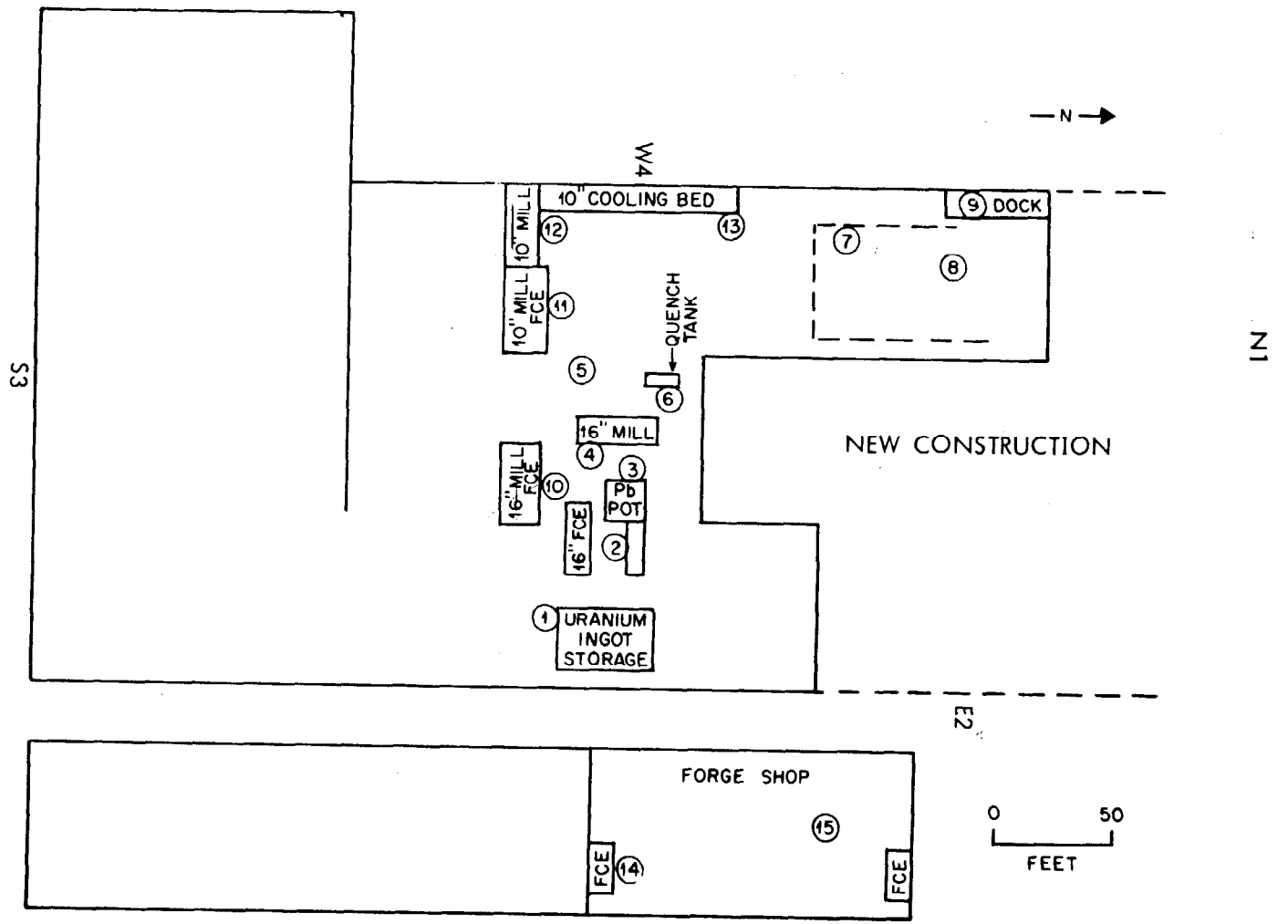

Fig. 2. Plan view of the 16-in. roll mill and forge shop.

ORNL DWG 77-5060

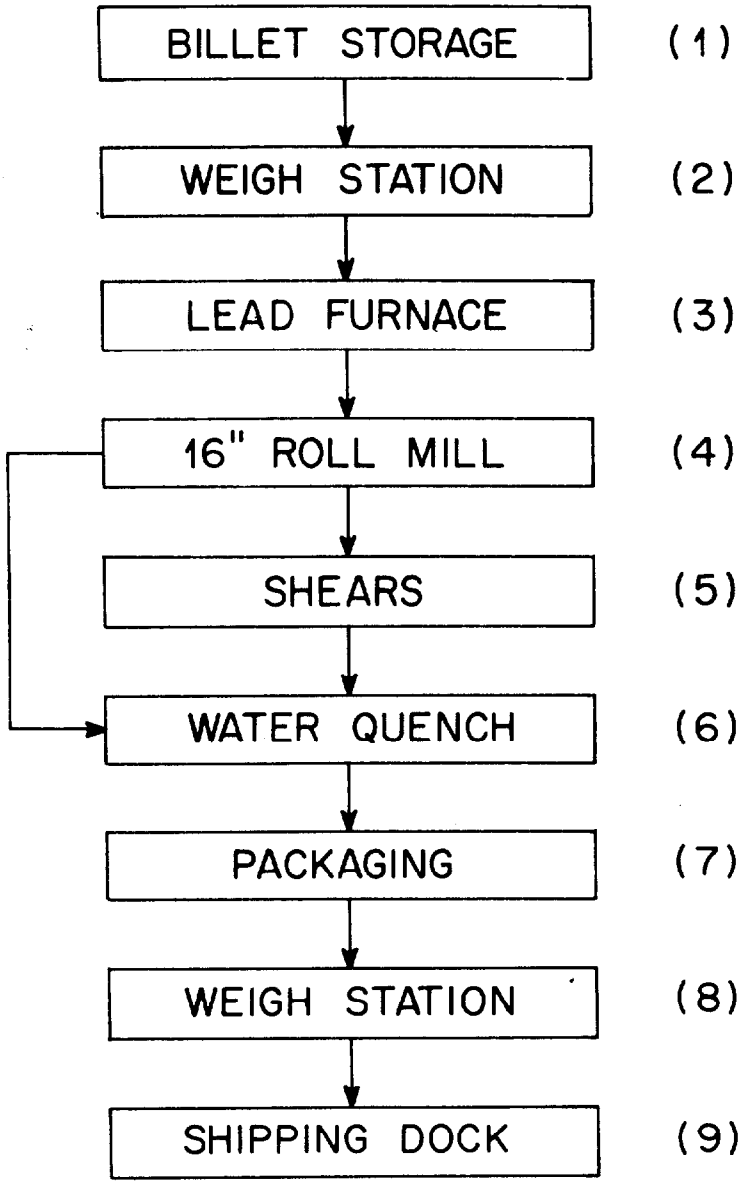

Fig. 3. Flow chart describing path of uranium during operations at Simonds.

ORNL DWG 77-5062

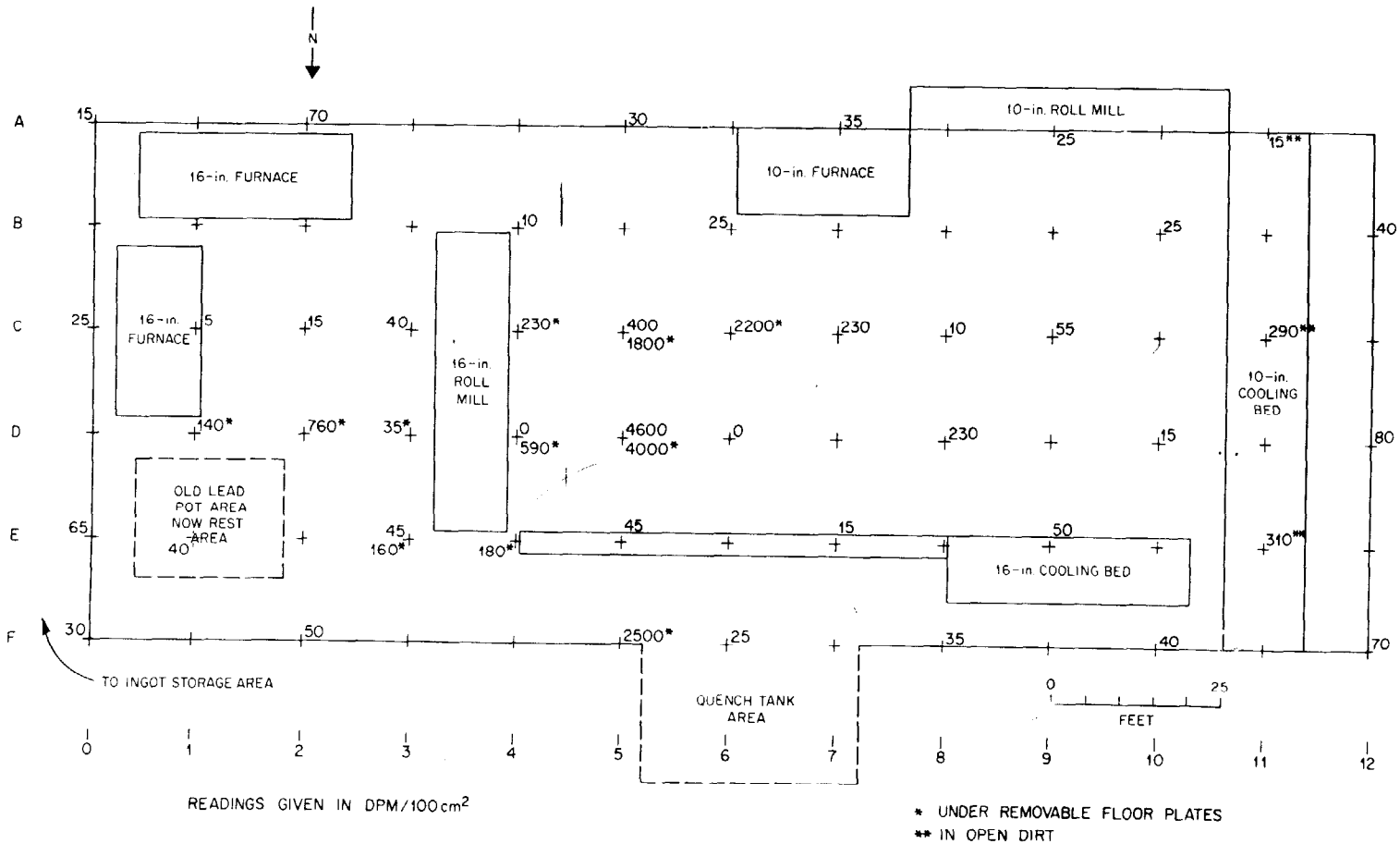

Fig. 4. Direct readings of alpha radiation levels on floor in rolling mill area.

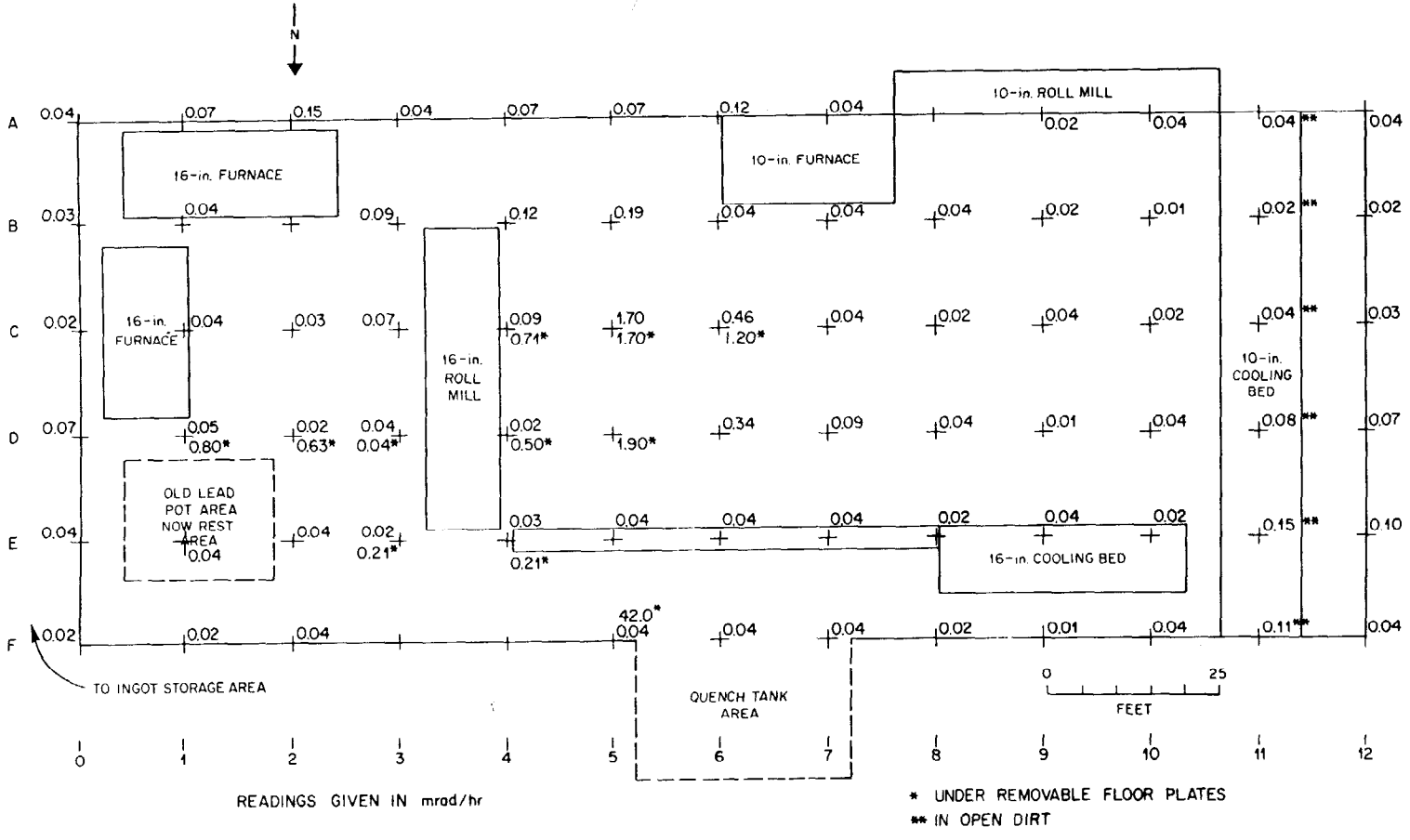

Fig. 5. Direct reading of beta-gamma radiation levels on floor in rolling mill area.

ORNL DWG 77-5064

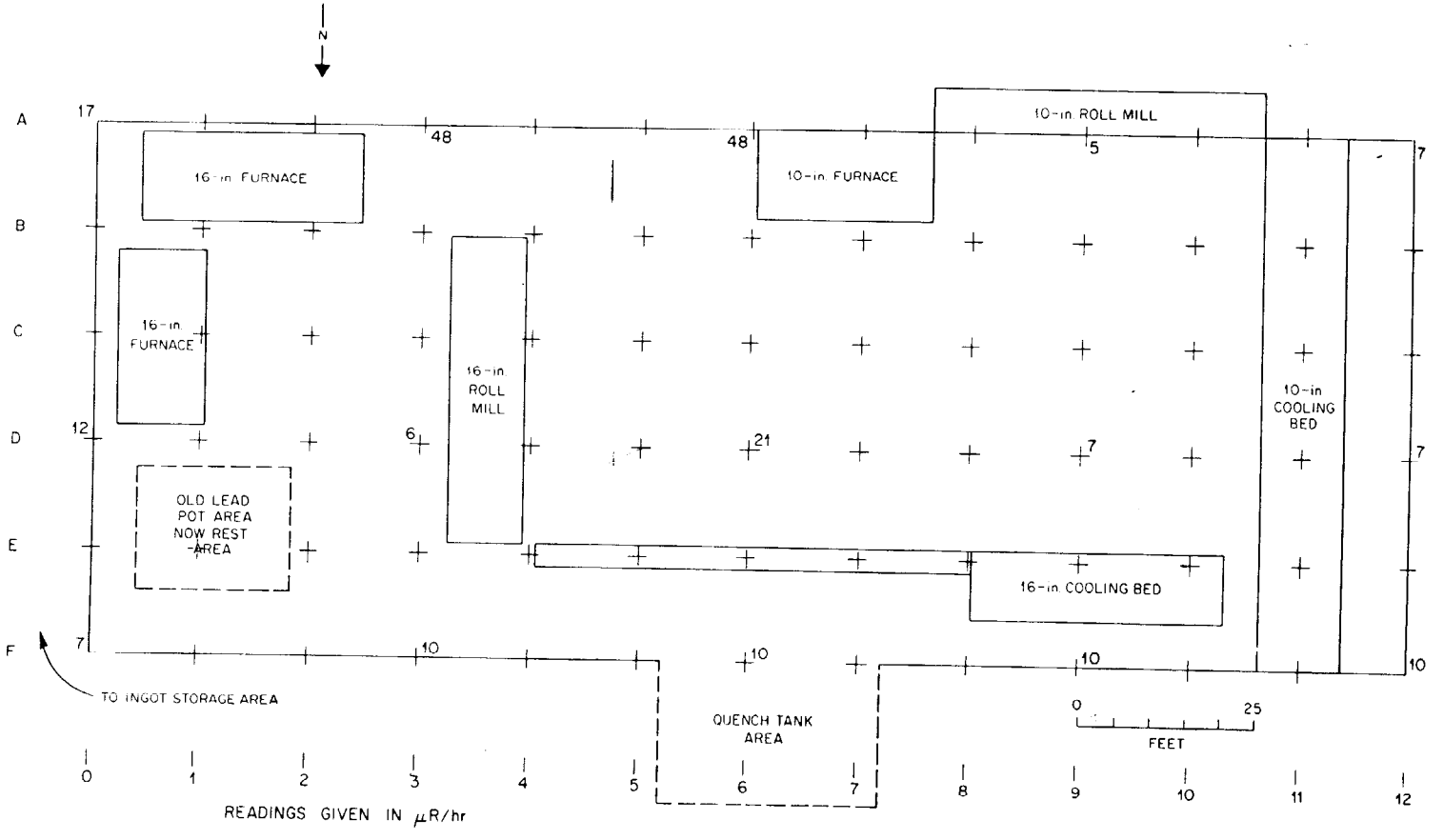

Fig. 6. External gamma radiation levels in rolling mill area.

ORNL DWG 77-5065

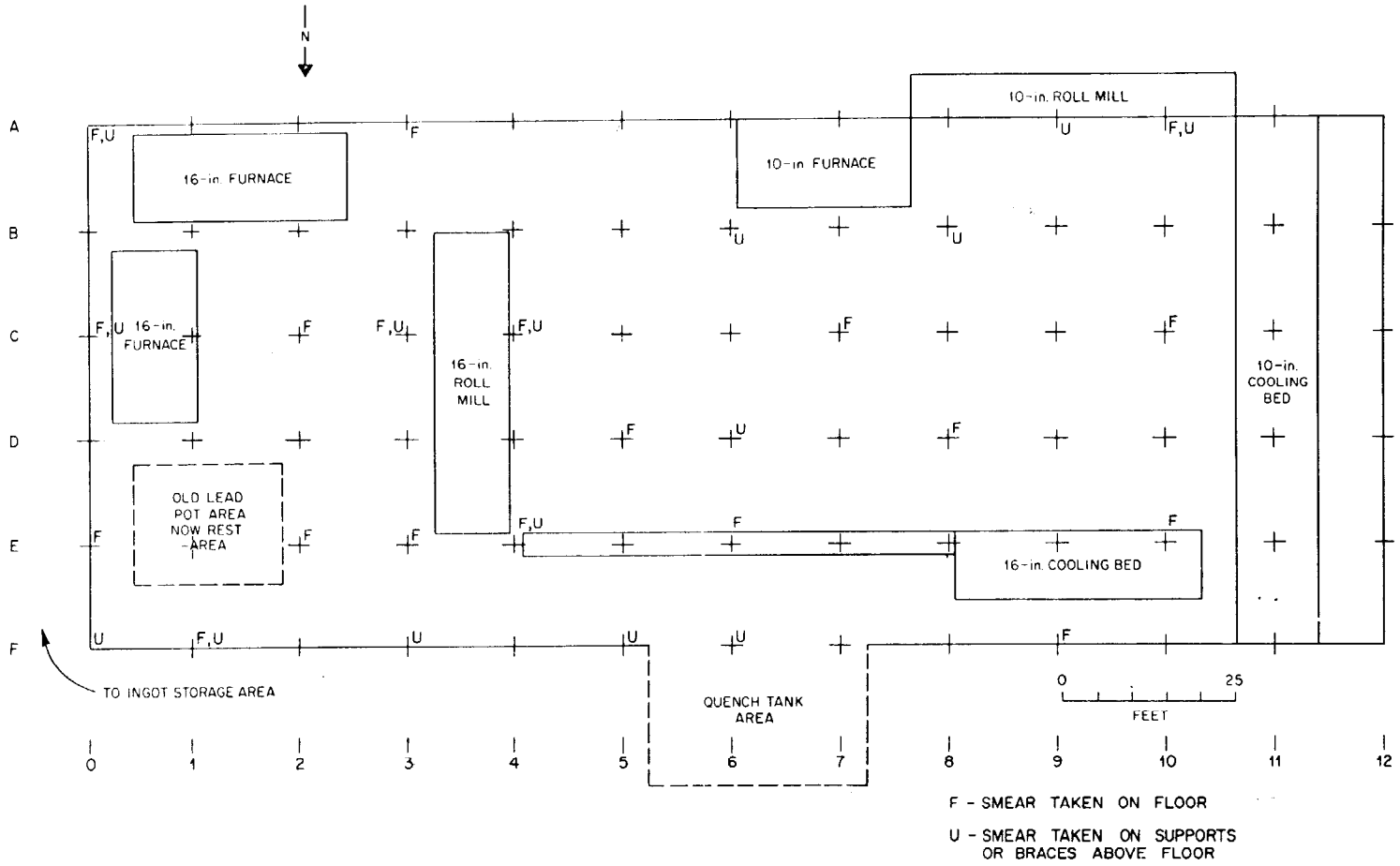

Fig. 7. Locations at which smear samples were taken in rolling mill area.

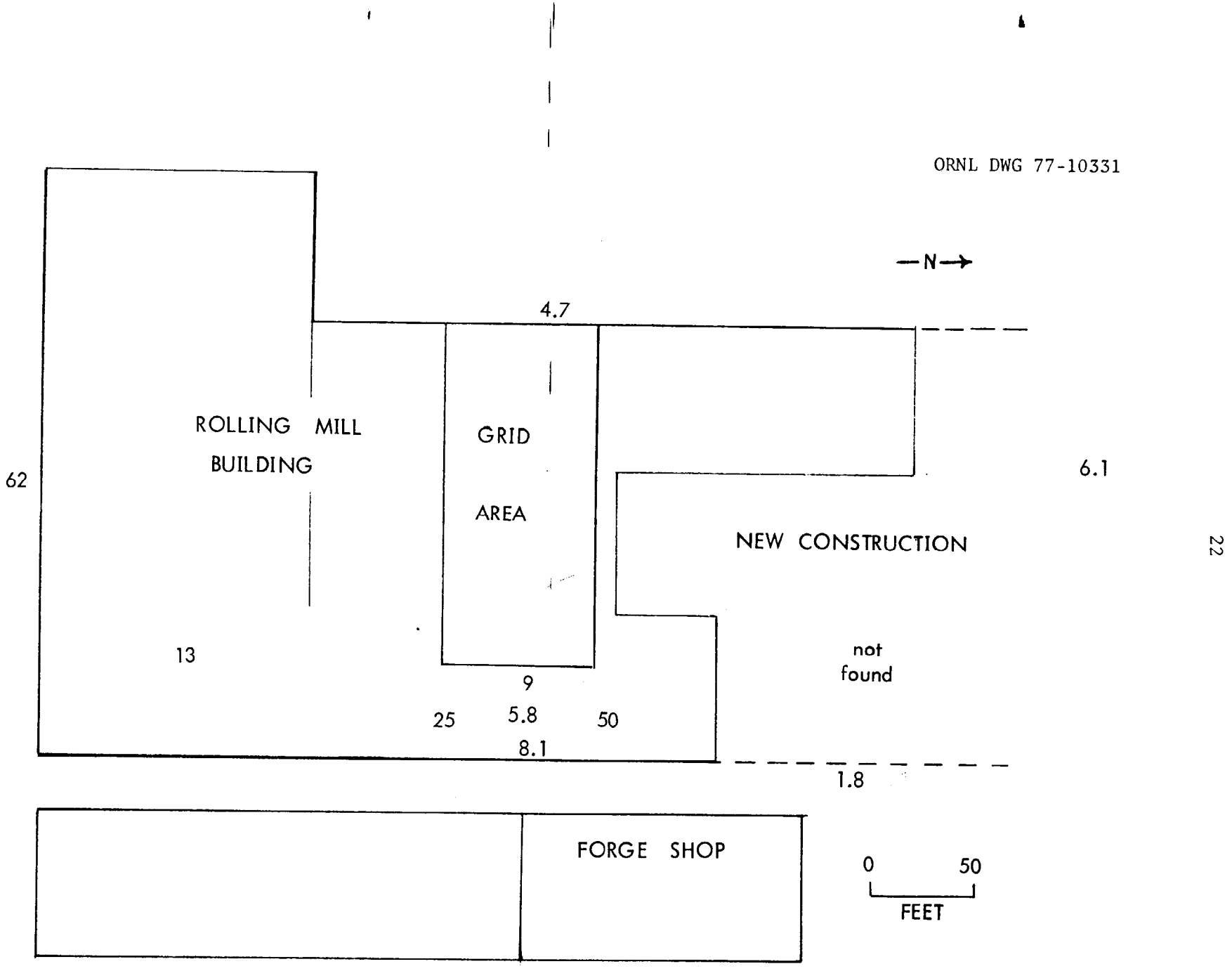

Fig. 8. Concentrations (pCi/g) of ^{238}U in samples taken outside the grid area.

ORNL DWG 79-19946

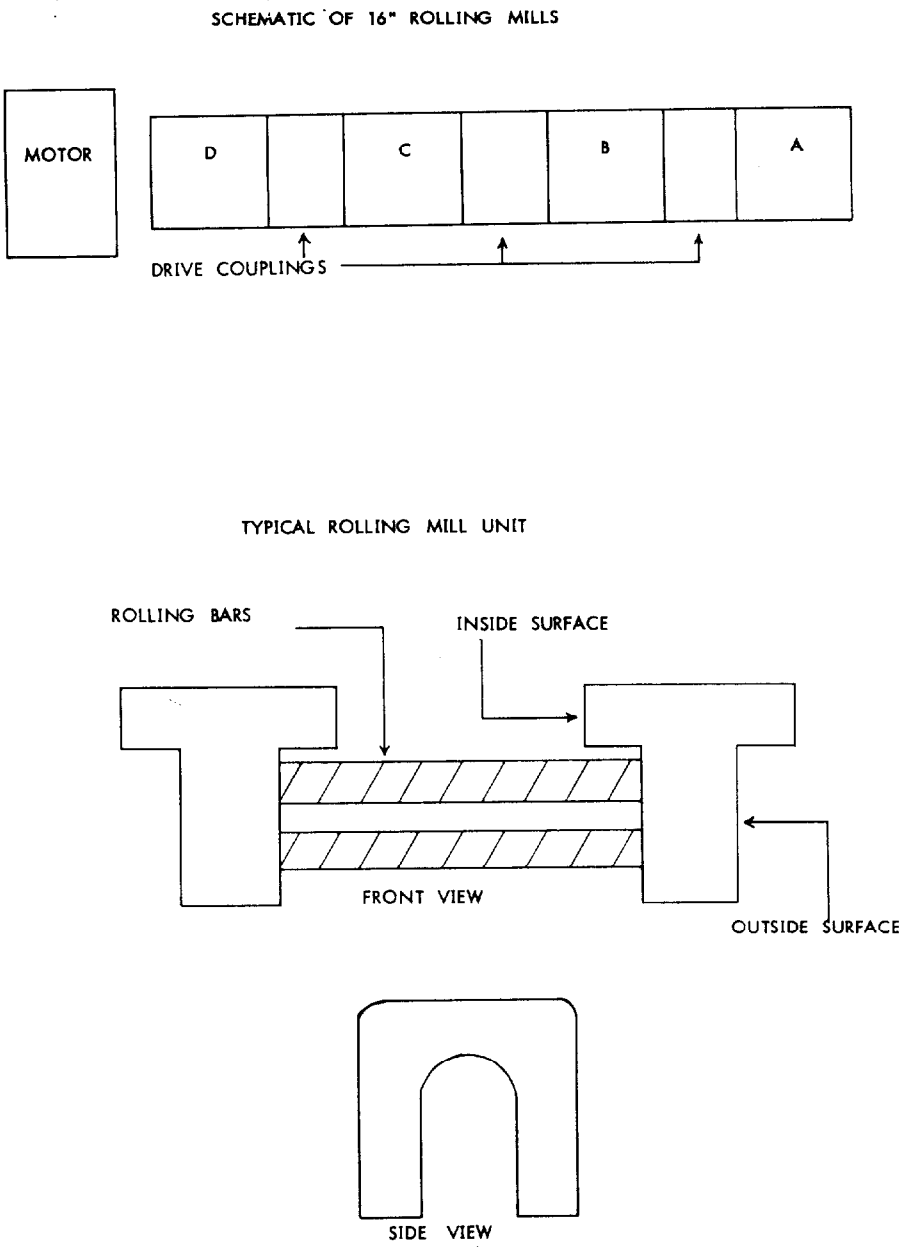

Fig. 9. Schematic diagram of 16-in. rolling mills.

Table 1. Direct readings of alpha contamination levels in buildings off the grid area

Location	Number of readings	Maximum reading (dpm/100 cm^2)	Average[a] reading (dpm/100 cm^2)	Standard dev.[b] of measurements (dpm/100 cm^2)
Uranium storage area	12	55	35	15
Forging shop	13	25	10	8
Grinding area	2	45	35	10
South of storage area	3	60	35	28
Southwest bay	8	30	10	10
West central bay	2	20	20	0
South of 10-in. roll mill	3	25	15	7
Northwest bay (north of grid area)	14	60	20	7

[a]The average reading $\bar{x}$ is computed using the formula $\bar{x} = \frac{1}{n} \sum_{i=1}^{n} \times i$, where $x_1, x_2, \ldots\ldots, x_n$ are the individual measurements.

[b]The standard deviation σ of measurements is computed using the formula

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}},$$

where $\bar{x}$ is the average reading and $x_1, x_2, \ldots\ldots, x_n$, are the individual measurements.

Table 2. Direct readings of beta-gamma radiation levels in buildings off the grid area

Location	Number of readings	Maximum reading (dpm/100 cm^2)	Average[a] reading (dpm/100 cm^2)	Standard dev.[b] of measurements (dpm/100 cm^2)
Uranium storage area	12	0.04	0.02	0.01
Forging shop	12	0.03	0.02	<0.01
Grinding area	2	0.02	0.02	0.01
South of storage area	3	0.04	0.03	0.01
Southwest bay	8	0.04	0.02	0.01
West central bay	2	0.04	0.04	<0.01
South of 10-in. roll mill	3	0.04	0.03	0.01
Northwest bay (north of grid area)	14	0.04	0.02	0.01

[a]The average reading $\bar{x}$ is computed using the formula $\bar{x} = \frac{1}{n} \sum_{i=1}^{n} \times i$, where $x_1, x_2, \ldots\ldots, x_n$ are the individual measurements.

[b]The standard deviation σ of measurements is computed using the formula

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}},$$

where $\bar{x}$ is the average reading and $x_1, x_2, \ldots\ldots, x_n$, are the individual measurements.

Table 3. External gamma radiation levels at 1 m above surface in buildings off the grid area

Location	Number of readings	Maximum reading (μR/hr)	Average[a] reading (μR/hr)	Standard dev.[b] of measurements (μR/hr)
Uranium storage area	12	8	6	1
Forging shop	13	6	5	1
Grinding area	2	6	5	1
South of storage area	3	7	6	2
Southwest bay	8	10	6	2
West central bay	2	10	10	0
South of 10-in. roll mill	3	12	8	4
Northwest bay (north of grid area)	14	8	5	1

[a]The average reading $\bar{x}$ is computed using the formula $\bar{x} = \frac{1}{n} \sum_{i=1}^{n} \times i$, where $x_1, x_2, \ldots\ldots x_n$ are the individual measurements.

[b]The standard deviation σ of measurements is computed using the formula

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}},$$

where $\bar{x}$ is the average reading and $x_1, x_2, \ldots\ldots, x_n$ are the individual measurements.

Table 4. Concentrations of ^{238}U, ^{232}Th, and ^{226}Ra in soil samples (pCi/g)

Sample	Location[a]	Depth	^{238}U	^{232}Th	^{226}Ra
1C	grid point 1C	surface	1,230	11.0	not found
2D	grid point 2D	surface	520	2.1	not found
3C	grid point 3C	surface	250	not found	not found
3D-1	grid point 3D	6 in.	420	not found	not found
3D-1	grid point 3D	12 in.	180	0.9	0.9
3E	grid point 3E	surface	110	0.3	not found
4C	grid point 4C	surface	730	2.1	not found
4D	grid point 4D	surface	310	1.5	not found
4E	grid point 4E	surface	210	2.1	not found
5C	grid point 5C	surface	10,000	8.4	not found
5F-1	grid point 5F	surface	21,000	not found	not found
5F-2	grid point 5F	6 in.	85	not found	not found
5F-3	grid point 5F	12 in.	190	not found	not found
6C-1	grid point 6C	surface	10,000	not found	not found
6C-2	grid point 6C	6 in.	920	not found	not found
6C-3	grid point 6C	12 in.	31	0.3	not found
6D	grid point 11E	surface	370	9.6	not found
B1	south of metal storage area	surface	25	0.5	0.7
B2	north of metal storage area	surface	50	0.7	not found
B3	west of metal storage area	surface	9.0	0.5	0.3
B4	east of metal storage area	surface	8.1	0.8	0.5
B5	center of metal storage area	surface	5.8	0.6	0.3
NE6	NE part of bldg.	surface	not found	not found	1.1
SE7	SE part of bldg.	surface	13	0.8	not found
N1	<10 ft N of roll mill bldg.	surface	6.1	0.8	0.7
E2	<10 ft E of roll mill bldg.	surface	1.8	0.4	not found
S3	near S entrance of roll mill bldg.	surface	62	not found	not found
W4	<10 ft W of roll mill bldg.	surface	4.7	0.7	0.6

[a]All samples collected at grid points were taken from below removable floor plates. For the location of grid points, see Fig. 4.

Table 5. Mass spectrometry analysis of residual uranium in soil

Sample No.	Wt. percent uranium	Atom percent		
		^{234}U	^{235}U	^{238}U
5F-1	6.73	0.0054	0.71	99.28
11-E	0.1	0.0052	0.71	99.28

Table 6. Concentrations of radionuclides in water samples (pCi/ml)

Sample	^{228}Th	^{230}Th	^{224}Ra	^{226}Ra	^{234}U	^{238}U
1	7.2×10^{-4}	3.6×10^{-5}	$<1.2 \times 10^{-3}$	$<1.2 \times 10^{-3}$	2.3×10^{-4}	1.8×10^{-4}
2	1.9×10^{-3}	5.0×10^{-5}	1.7×10^{-3}	1.7×10^{-3}	1.5×10^{-3}	1.4×10^{-3}
3	6.3×10^{-4}	5.9×10^{-4}	1.8×10^{-3}	1.8×10^{-3}	1.1×10^{-3}	9.0×10^{-4}
MPC_w[a] (soluble)	7	2	2	3.0×10^{-2}	30	40

[a] 10 CFR 20, Appendix B.

Results of direct measurements of alpha and beta-gamma contamination made on the 16-in. rolling mills

Location on mill	Directly measured alpha contamination level (dpm/100 cm^2)		Beta-gamma dose rate at 1 cm (mrad/hr)	
	Average	Maximum	Average	Maximum
Left outside	500	500	0.1	0.75
Right outside	200	200	0.04	0.40
Reel	200	200	0.80	0.80
Left outside	200	1500	0.1	1.75
Left inside	200	200	0.1	2.5
Right outside	200	600	0.1	3.5
Right inside	NR[a]	NR	0.1	1.0
Entire mill	100	100	0.1	0.1
Left outside	200	200	0.1	0.1
Right outside	300	300	0.2	0.2
Left inside	200	300	0.05	0.05
Right inside	300	600	0.15	1.75
Left front	200	200	0.15	1.5
Right front	200	200	0.1	3.5
Left rear	200	200	0.1	0.1
Right rear	300	300	1.5	1.5

[a] Not taken.

[b] Mill not used for uranium or thorium rolling.

APPENDIX I

DESCRIPTION OF RADIATION SURVEY METERS AND SMEAR COUNTERS

RADIATION SURVEY METERS

Alpha Survey Meters

Two types of alpha survey meters are used to measure alpha radioactivity on surfaces. One type of instrument uses a ZnS scintillator and the other uses a gas-flow proportional counter to detect the alpha radiation.

The alpha scintillation survey meter consists of a large area (100 cm^2) ZnS detector with a photomultiplier tube in the probe which is coupled to a portable scaler/ratemeter (see Fig. I-A). The ZnS detector is covered with a 5-mil aluminized mylar sheet in order to make the instrument light-tight. The mylar, in turn, is covered with a grid to prevent puncturing the detector when surveying over rough surfaces. This instrument is capable of measuring alpha surface contamination levels of a few dpm/100 cm^2 but must be used in the scaler mode for this purpose. It is highly selective for densely ionizing radiation such as alpha particles; the instrument is relatively insensitive to beta and gamma radiation.

The gas-flow proportional counter uses propane gas as the detection medium. Through front panel meter readings, it can be used to measure alpha contamination levels from a few hundred dpm/100 cm^2 to several hundred thousand dpm/100 cm^2. If individual pulses are counted, this instrument can also be used for measurements down to a few dpm/100 cm^2. The probe has a surface area of approximately 61 cm^2 and has a 2.5-mil aluminized mylar covering with a protective grid. Due to the protective grid, the active area of the probe is 50 cm^2. It is relatively insensitive to other alpha radiation. This instrument, shown in Fig. I-B, is manufactured by the Eberline Instrument Company as their model PAC-4G meter with a probe.

Both of these instruments are calibrated at ORNL using ^{239}Pu alpha sources. While each instrument is individually calibrated, the calibration factors are typically 5-6 dpm/cpm.

Beta Survey Meter

A portable Geiger-Mueller (G-M) survey meter is the primary instrument for measuring beta-gamma radioactivity. The G-M tube is a halogen-quenched stainless steel tube having a 30 mg/cm^2 wall thickness and presenting a cross-sectional area of approximately 10 cm^2. Since the G-M tube is sensitive to both beta and gamma radiation, measurements are taken in both an open-window and a closed-window configuration. Beta radiation cannot penetrate the closed window, and, thus, the beta reading can be determined by taking the difference between the open and closed window readings. This meter is shown in Fig. I-C.

The G-M survey meter was calibrated at ORNL for gamma radiation using a National Bureau of Standards standard Ra source. The gamma calibration factor is typically of the order of 2600 cpm/mR/hr.

In order to assess beta-gamma surface dose rates from uranium contaminated surfaces using this instrument, a field calibration was performed. The G-M survey meter was compared with a Victoreen Model 440 ionization chamber (see Fig. I-D) and was found to produce 2400 cpm/mrad per hr (from a best-fitting line with a coefficient of determination of $r^2 = 0.90$) for a wide variety of surfaces.

Gamma Scintillation Survey Meter

A portable survey meter using a NaI scintillation probe is used to measure low-level gamma radiation exposure. The scintillation probe is a 3.2 x 3.8-cm NaI crystal coupled to a photomultiplier tube. This probe is connected to a Victoreen Model Thyac III rate meter (see Fig. I-E). This unit is capable of measuring radiation levels from a few μR/hr to several hundred μR/hr. This instrument is calibrated at ORNL with an NBS standard ^{226}Ra source. Typical calibration factors are of the order of 300 cpm/μR per hr.

SMEAR COUNTERS

Alpha Smear Counter

This detector assembly, used for the assay of alpha emitters on smear paper samples, consists of a light-tight sample holder, a zinc sulfide phosphor and a photomultiplier tube. This detector assembly was used with electronic components housed in a portable NIM bin (see Fig. I-F). The electronics package consisted of a preamplifier, an ORTEC 456 high voltage power supply, a Tennelec TC 211 linear amplifier and a Tennelec TC 545 counter-timer.

The alpha smear counter was used in the field and was calibrated daily using an alpha source with a known disintegration rate.

Beta Smear Counter

The beta smear counter consisted of a thin mica window ($\sim$2 mg/cm^2) G-M tube mounted on a sample holder and housed in a 23-cm diam x 35-cm high lead shield. Located under the counter window is a slotted sample holder, accessible through a hinged door on the shield. An absorber can be interposed in the slot between the sample and the counter window to determine relative beta and gamma contributions to the observed sample counting rate. The electronics for this counter were housed in a portable NIM bin and consisted of a Tennelec TC 148 preamplifier, an ORTEC 456 high voltage power supply and a Tennelec TC 545 counter-timer.

This unit, shown in Fig. I-F, was used in the field to measure beta activity on smear papers and was calibrated daily using a beta standard of known activity.

ORNL Photo 6705-76

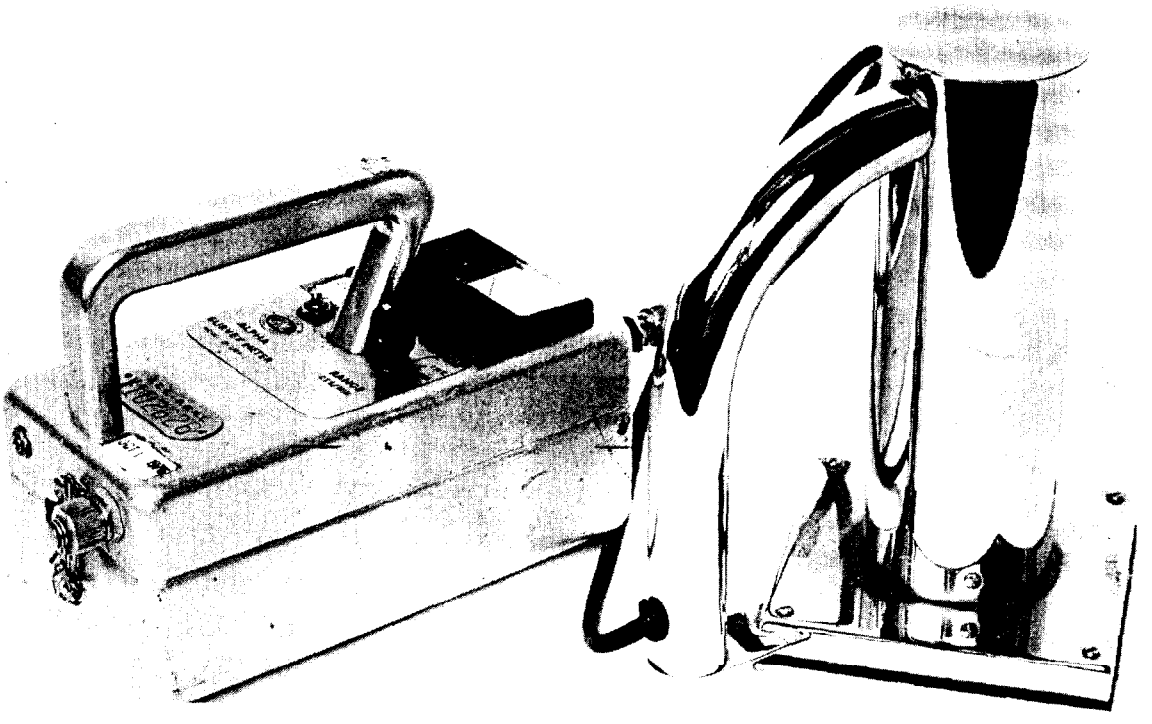

Fig. I-A. Alpha scintillation survey meter.

ORNL Photo 6715-76

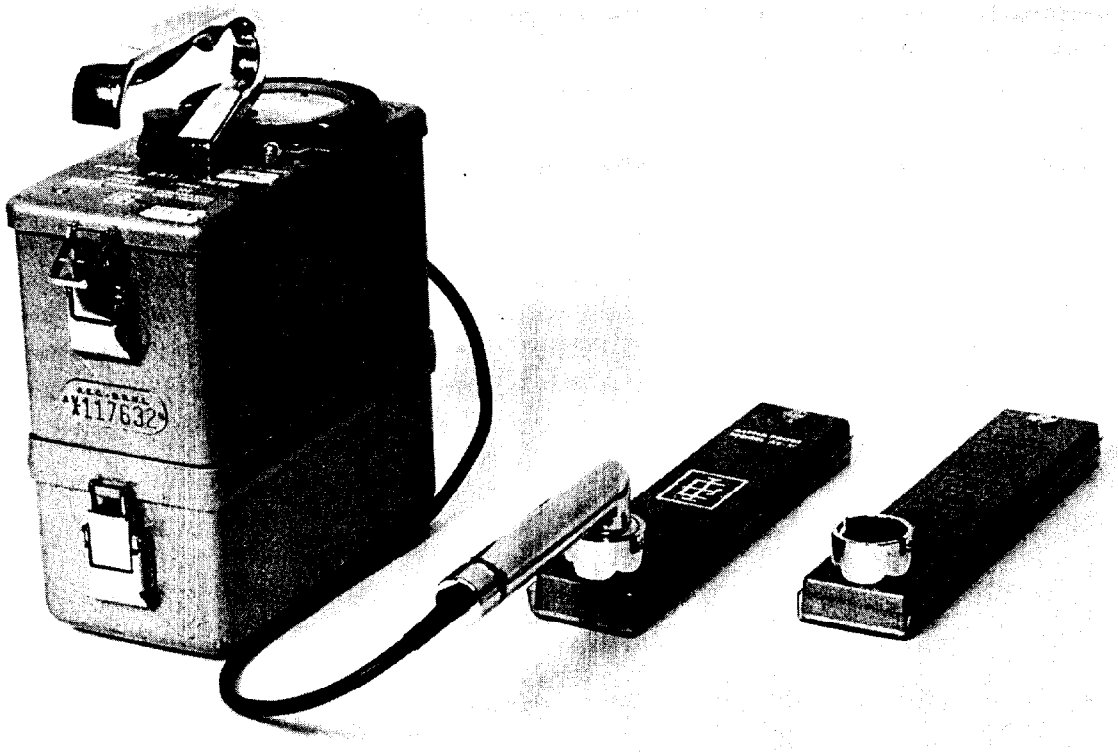

Fig. I-B. Gas-flow proportional alpha survey meter.

ORNL Photo 6704-76

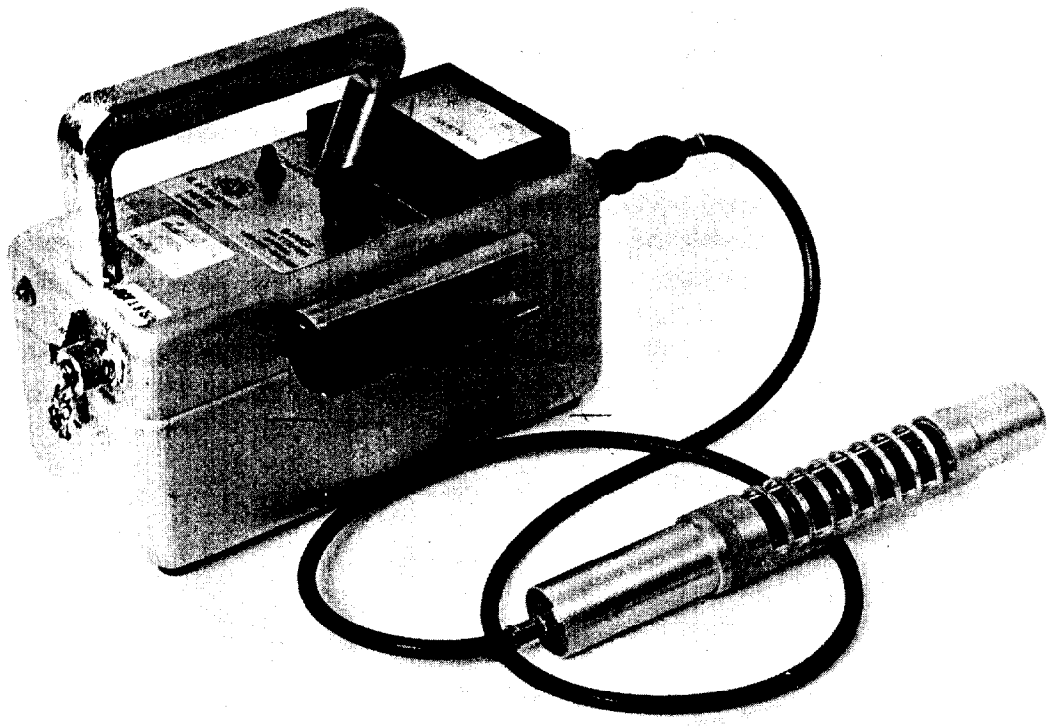

Fig. I-C. Geiger-Mueller survey meter.

ORNL Photo 6710-76

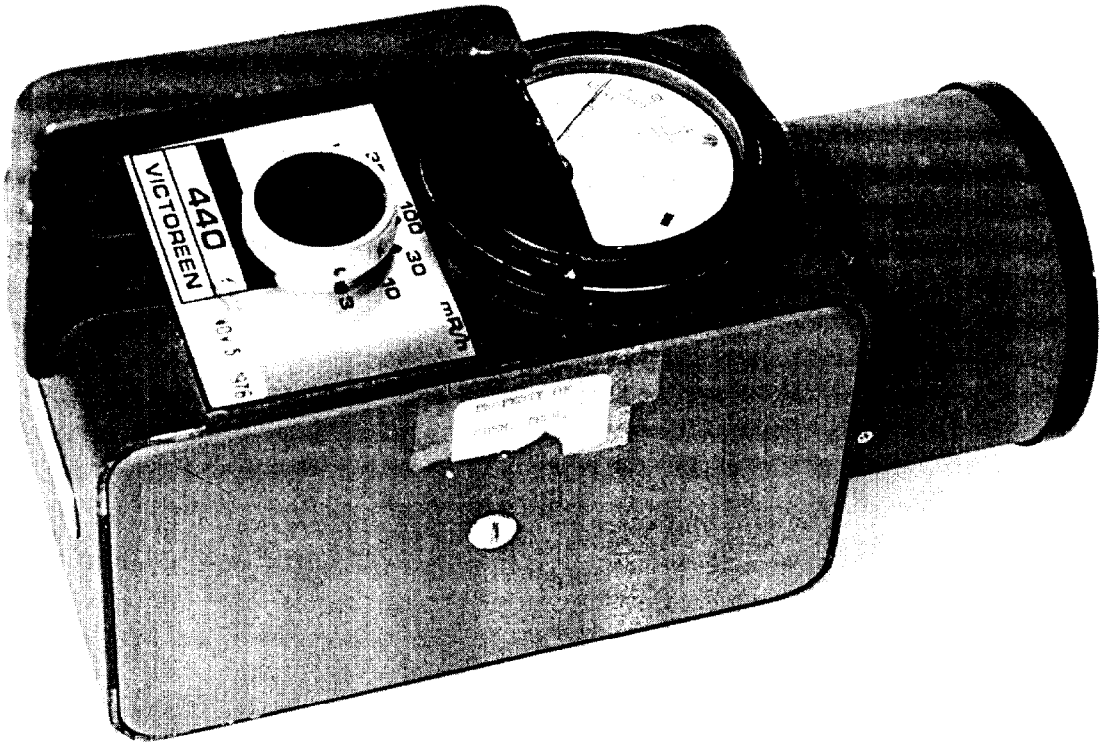

Fig. I-D. Victoreen Model 440 ionization chamber.

ORNL Photo 6707-76

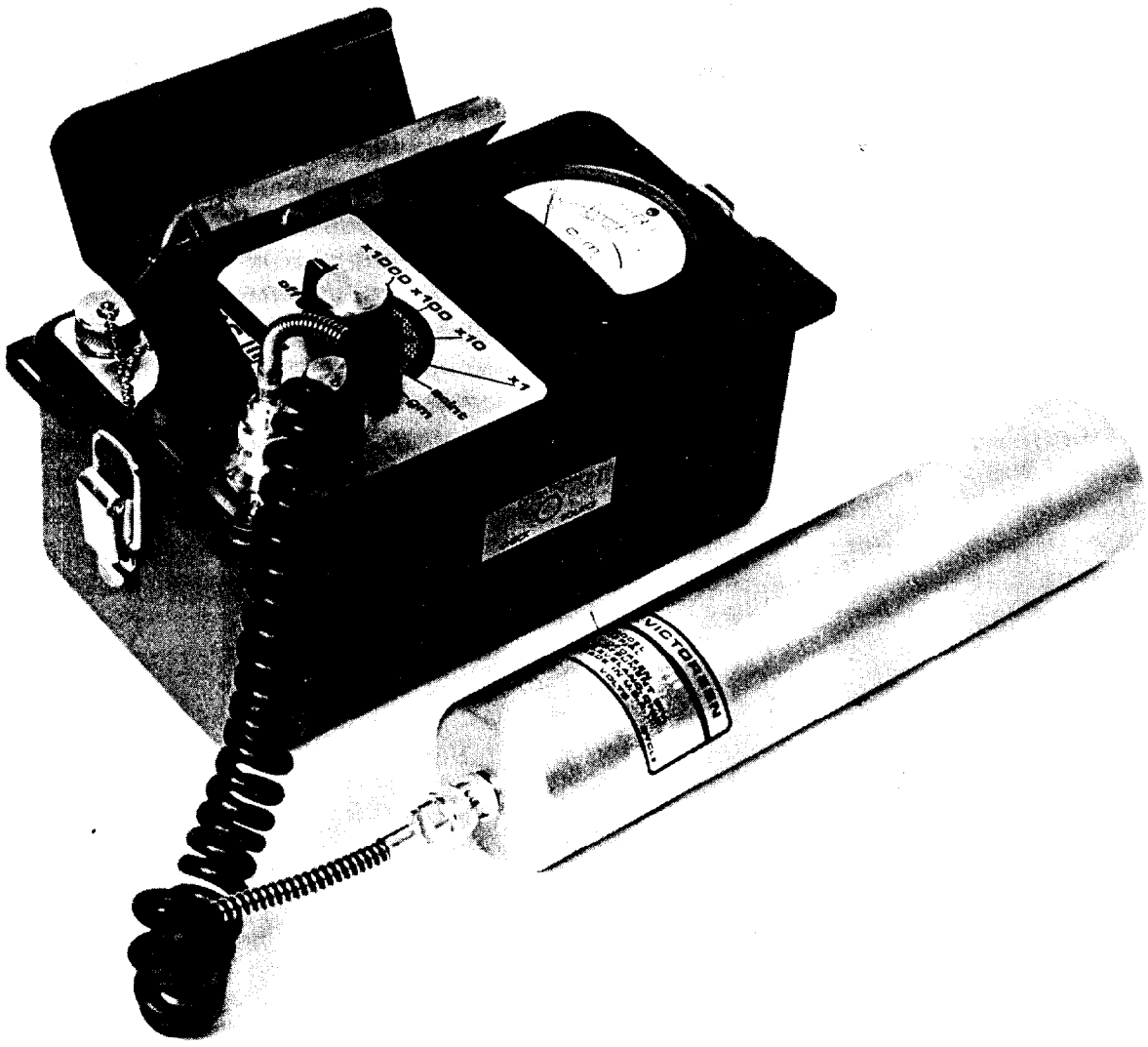

Fig. I-E. Gamma scintillation survey meter.

ORNL Photo 1070-78

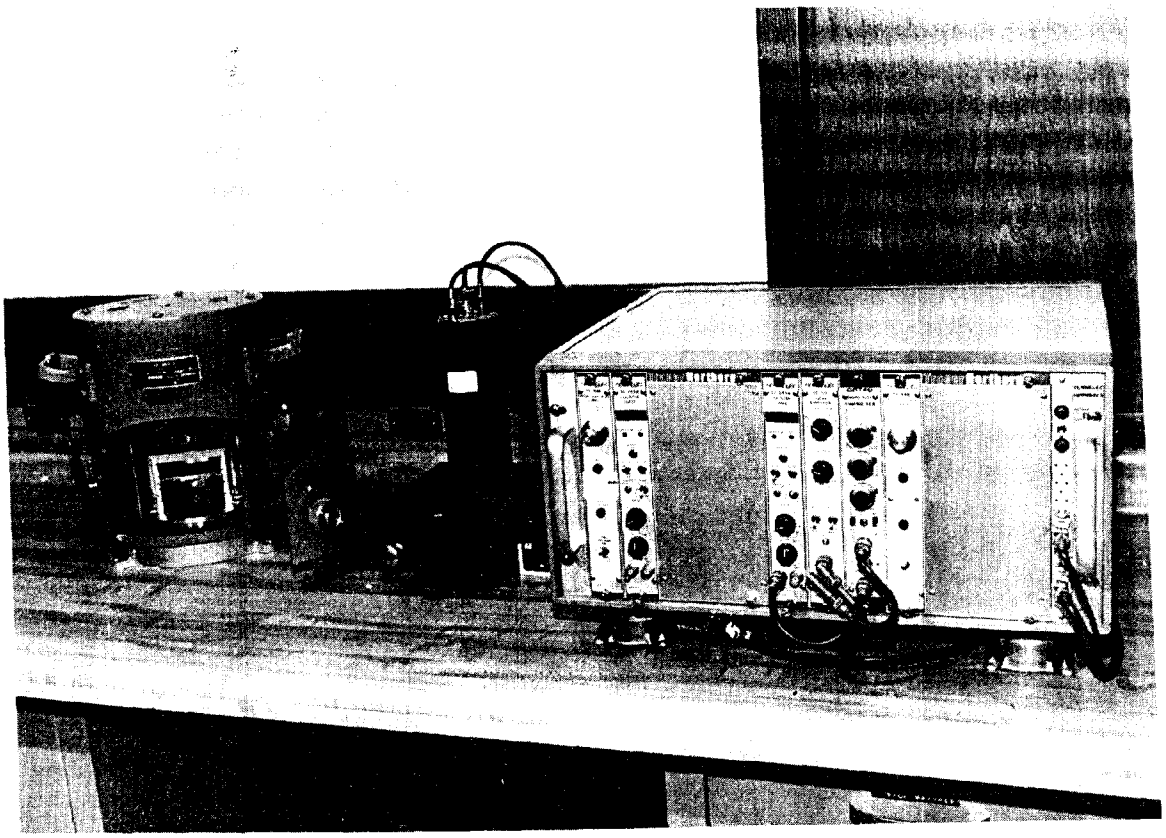

Fig. I-F. Smear counter and associated electronics. The beta counter is on the left and the alpha counter is on the right.

APPENDIX II

DESCRIPTION OF THE TECHNIQUES FOR THE MEASUREMENT OF RADON AND RADON DAUGHTER CONCENTRATIONS IN AIR

TECHNIQUE FOR THE MEASUREMENT OF ^{222}Rn PROGENY CONCENTRATIONS IN AIR

An alpha spectrometry technique has been refined by Kerr[I-1,I-2] for the measurement of ^{222}Rn progeny concentrations in air. From one integral count of the ^{218}Po alpha activity and two integral counts of the ^{214}Po alpha activity, the concentrations in air of ^{218}Po, ^{214}Bi, and ^{214}Pb may be calculated.

Particulate ^{222}Rn daughters attached to airborne dust are collected on a membrane filter with a pore size of 0.4 microns. A sampling time of 5 min and a flow rate of 12 LPM are used. This filter sample is then placed under a silicon surface barrier detector and counted. The detector and counting system used for radon daughter measurements are shown in Fig. II-A. Usually, counting of this kind is performed with a vacuum between the sample and the detector which requires a complicated sample holder and time-consuming sample changing methods. Experiments at this laboratory have shown that ease in sample handling is obtained with little loss in resolution when helium is used as a chamber fill gas.[I-3] In this counter, helium is flowed between the diode and the filter sample, which are separated by a distance of 0.5 cm. One integral count of the ^{218}Po alpha activity is obtained from 2 to 12 min, and two integral counts of the ^{214}Po activity are obtained from 2 to 12 min and 15 to 30 min, respectively. All counting intervals are referenced to $t = 0$ at the end of sampling.

The equations describing the ^{222}Rn progeny atoms collection rates on the filter are of the form

$$\frac{dn_i(t)}{dt} = C_i v + \lambda_{i-1} n_{i-1}(t) - \lambda_i n_i(t), \qquad (1)$$

where

n_i = number of the ith species of atom on the filter as a function of

λ_i = radioactive decay constant of the ith species (min^{-1}),

C_i = concentration of the ith species (atoms l^{-1}), and

v = air sampling flow rate (liters min^{-1}).

The solution of Eq. (1) is of the form

$$y = e^{-ax} \left[y_0 = \int F(x)\ e^{ax} dx \right]. \qquad (2)$$

From the general form of the solution, specific equations can be obtained describing the number of each ^{222}Rn decay product collected on the filter as a function of time. Also by letting v = 0 in Eq. (1), a set of equations describing the decay on the filter of each ^{222}Rn progeny can be obtained. The equations describing the decay of ^{222}Rn progeny on the filter can be integrated and related to the integral counts obtained experimentally. Values for the total activities of ^{218}Po, ^{214}Pb, and ^{214}Bi on the filter at the end of sampling are obtained by applying matrix techniques. The airborne concentrations are obtained by solving the equations describing the atom collection rates on the filter. A computer program has been written to perform these matrix operations, to calculate the air concentrations of the radon progeny, and to estimate the accuracy of the calculated concentrations.

TECHNIQUE FOR THE MEASUREMENT OF RADON CONCENTRATIONS IN THE AIR

A Lucas Chamber (Fig. II-B) consists of a 95-ml glass flask, coated inside with a uniform layer of zinc sulfide. For measurements of radon concentration in the air, the flask is evacuated to a pressure of 50 microns. The flask is then taken to a location where a sample is desired and the collection valve is opened. After collection of air in the flask, sample counting is delayed 3 to 4 hr to allow the radon daughters to attain equilibrium. Alpha particles from the radon daughters produce scintillations in the zinc sulfide. The sample is normally counted for 1000 sec with a photomultiplier tube assembly. A calibration performed at ORNL using a known radon concentration indicated that the conversion factor is 2.02 pCi/liter per cpm. After the sample has been counted, the flask is again evacuated to 50 microns to prevent contamination.

REFERENCES

II-1. G. D. Kerr, *Measurement of Radon Progeny Concentration in Air by Alpha-Particle Spectrometry*, Oak Ridge National Laboratory Report ORNL/TM-4924 (July 1975).

II-2. G. D. Kerr, "Measurement of Radon Progeny Concentrations in Air," *Trans. Am. Nuc. Soc.* 17, 541 (1973).

II-3. P. T. Perdue, W. H. Shinpaugh, J. H. Thorngate, and J. A. Auxier, "A Convenient Counter for Measuring Alpha Activity of Smear and Air Samples," *Health Phys.* 26, 114 (1974).

ORNL Photo 1077-78

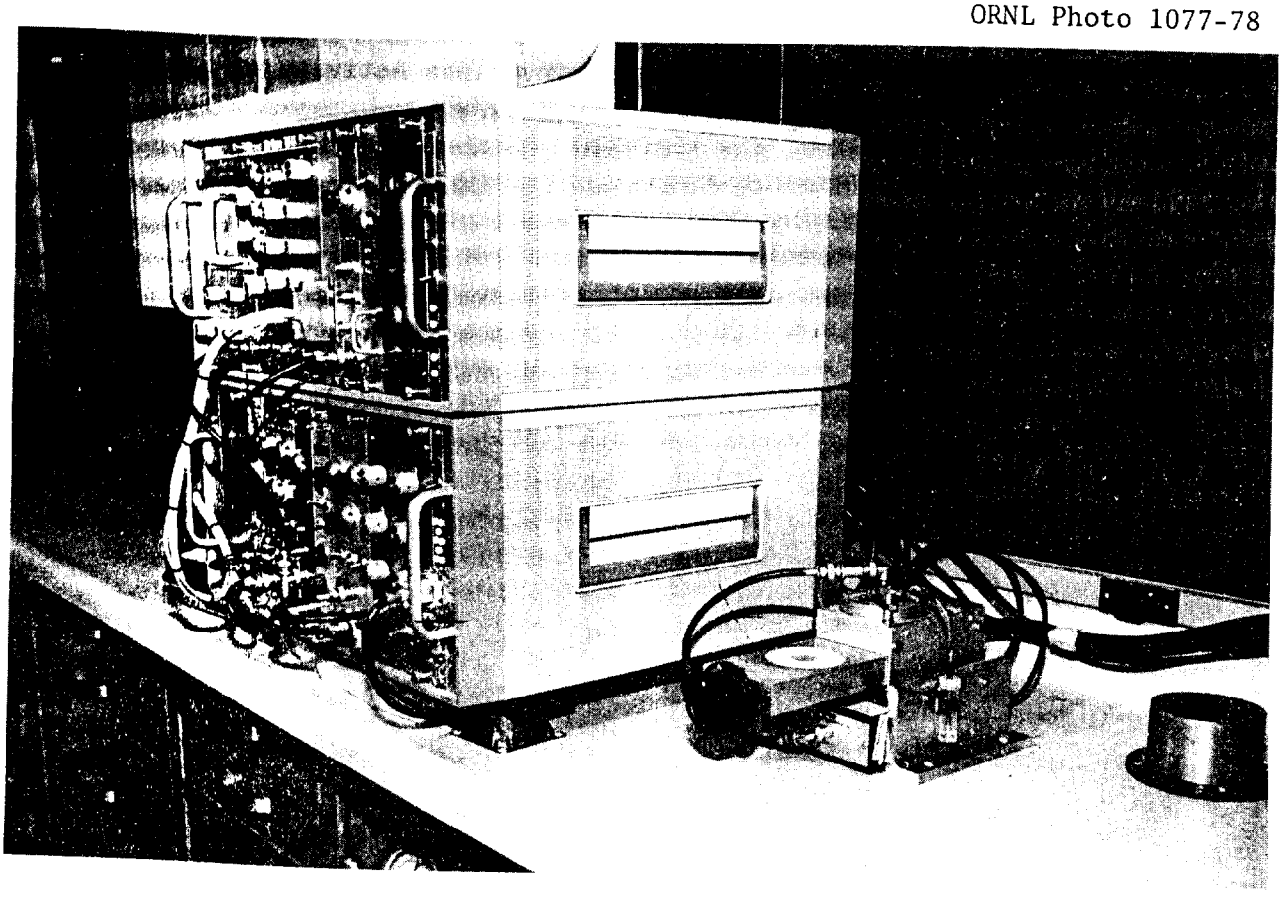

Fig. II-A. System used for measurement of radon daughter concentrations.

ORNL Photo 1083-78

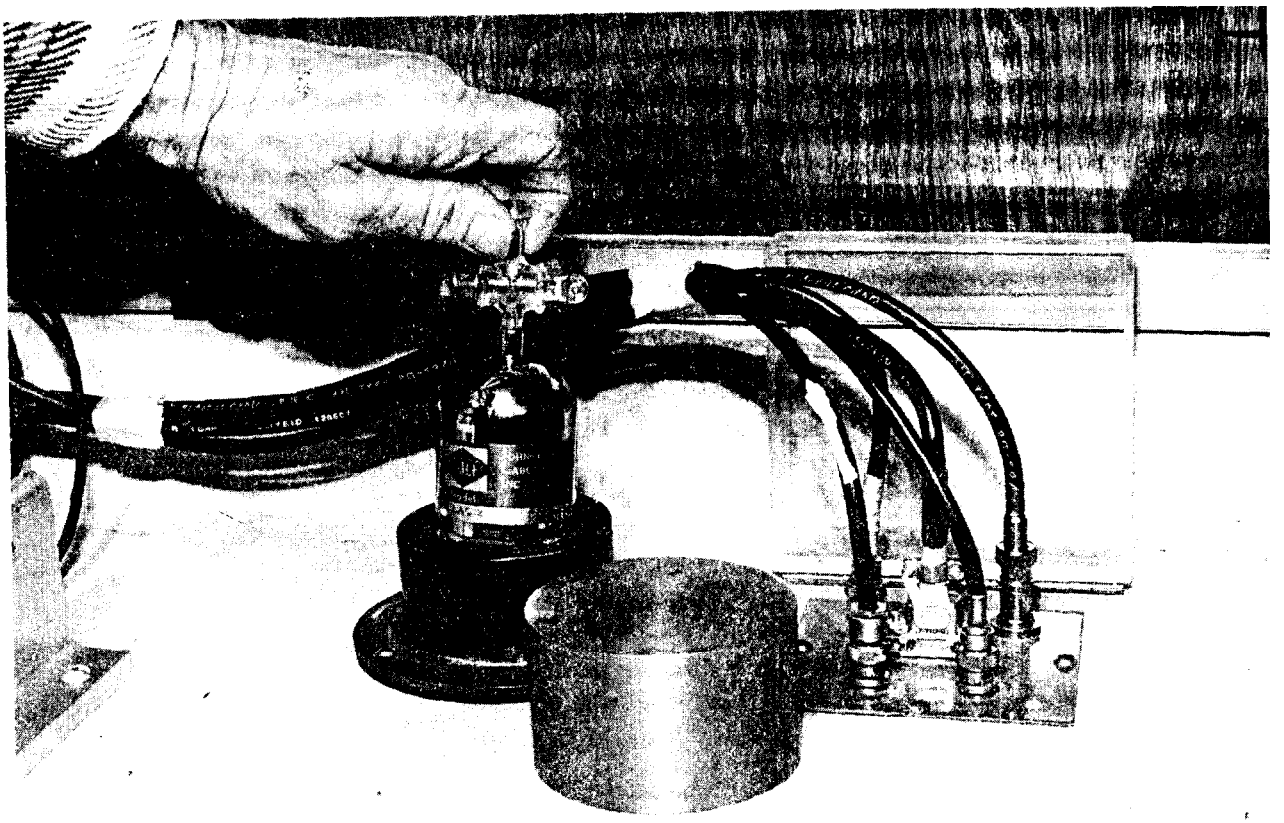

Fig. II-B. Lucas chamber.

APPENDIX III

DESCRIPTION OF Ge(Li) DETECTOR AND SOIL COUNTING PROCEDURES

DESCRIPTION OF Ge(Li) DETECTOR SYSTEM

A holder for twelve 30-cc polyethylene bottles (standard containers for liquid scintillation samples) and a background shield have been designed for use with a 50-cc Ge(Li) detector system in laboratory counting of radioactivity in environmental samples (see Figs. III-A and III-B). During counting of the samples, the holder is used to position ten of the sample bottles around the cylindrical surface of the detector, parallel to and symmetric about its axis, and two additional bottles across the end surface of the detector, perpendicular to and symmetric with its axis. With a 300-cc sample and a graded shield developed for use with the system, it is possible to measure 1 pCi/g of ^{232}Th or ^{226}Ra with an error of ± 10% or less.

Pulses are sorted by a 4096-channel analyzer (see Fig. III-C), stored on magnetic tape, and subsequently entered into a computer program which uses an iterative least-squares method to identify radionuclides corresponding to those gamma-ray lines found in the sample. The program relies on a library of radioisotopes which contains approximately 700 isotopes and 2500 gamma-rays and which runs continuously on the IBM-360 system at ORNL. In identifying and quantifying ^{226}Ra, six principal gamma-ray lines are analyzed. Most of these are from ^{214}Bi and correspond to 295, 352, 609, 1120, 1765, and 2204 KeV. An estimate of the concentration of ^{238}U is obtained from an analysis of the 93 KeV line from its daughter ^{234}Th.

ORNL Photo 2172-75

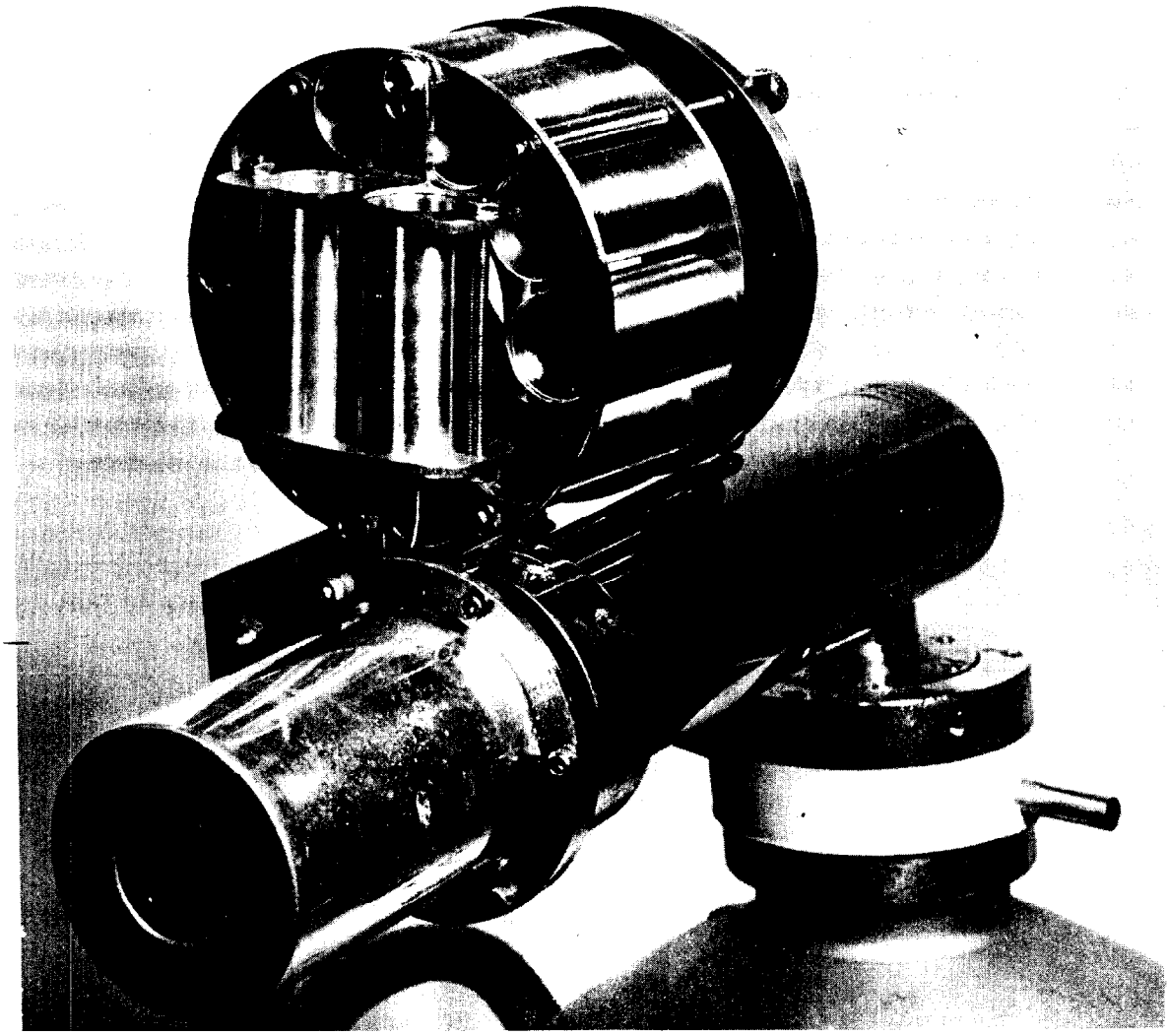

Fig. III-A. Holder for Ge(Li) detector system.

ORNL Photo 2171-75

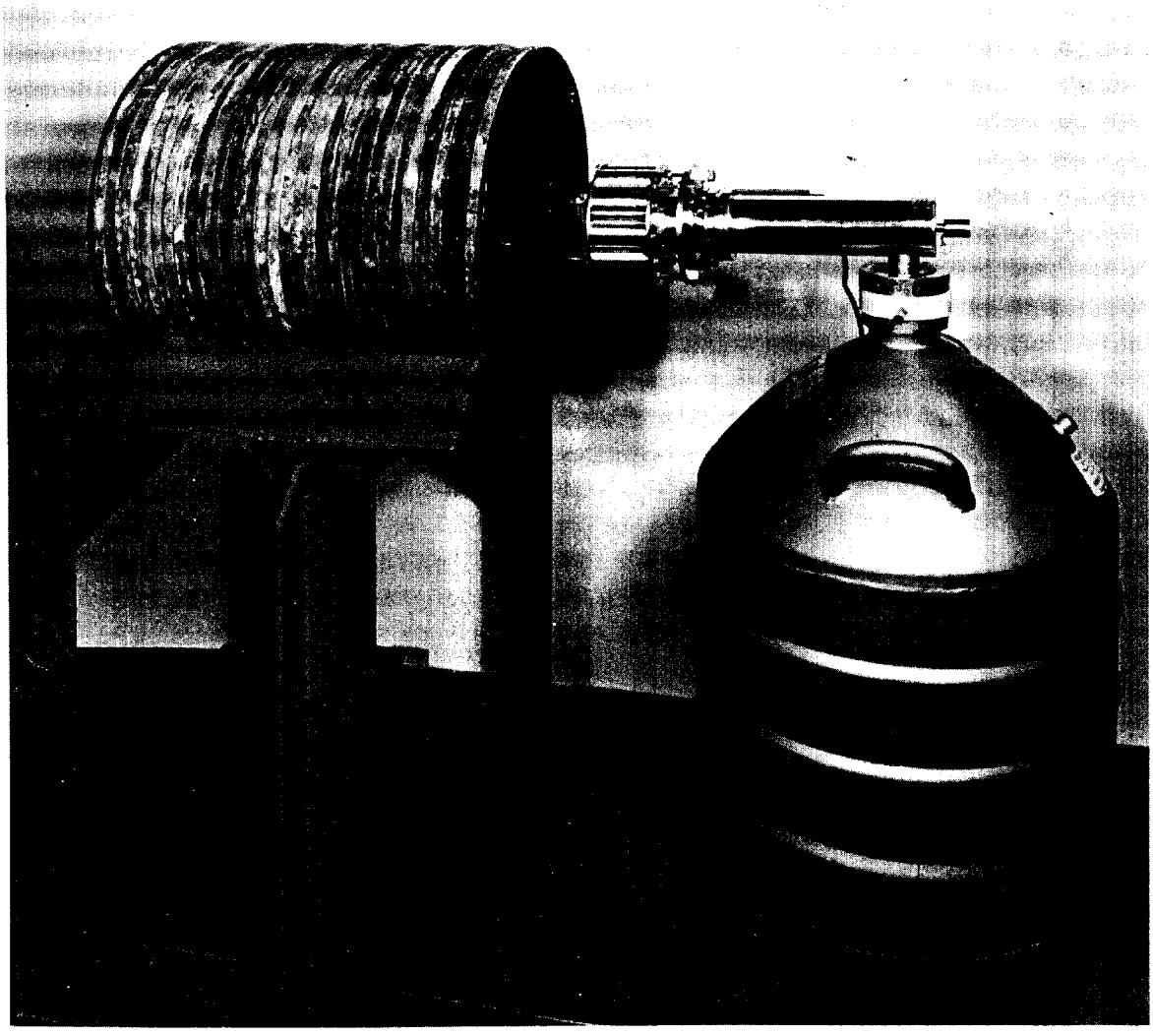

Fig. III-B. Ge(Li) detector system.

ORNL Photo 6711-76

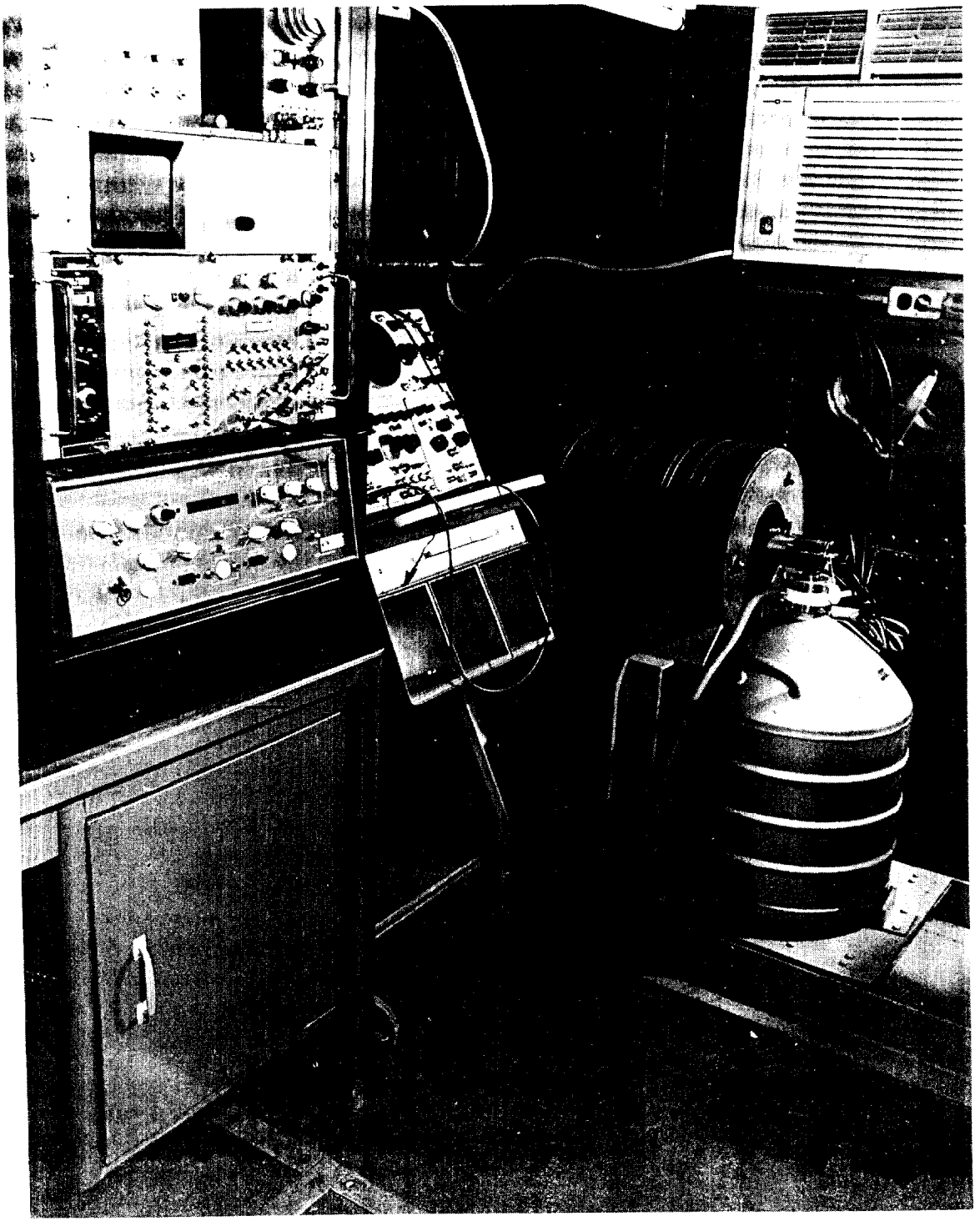

Fig. III-C. 4096-channel analyzer.

APPENDIX IV

PERTINENT RADIOLOGICAL REGULATIONS, STANDARDS, AND GUIDELINES

Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material

U.S. Nuclear Regulatory Commission
Division of Fuel Cycle and
Material Safety
Washington, D.C. 20555

November 1976

The instructions in this guide in conjunction with Table IV-1 specify the radioactivity and radiation exposure rate limits which should be used in accomplishing the decontamination and survey of surfaces or premises and equipment prior to abandonment or release for unrestricted use. The limits in Table IV-1 do not apply to premises, equipment, or scrap containing induced radioactivity for which the radiological considerations pertinent to their use may be different. The release of such facilities or items from regulatory control will be considered on a case-by-case basis.

1. The licensee shall make a reasonable effort to eliminate residual contamination.
2. Radioactivity on equipment or surfaces shall not be covered by paint, plating, or other covering material unless contamination levels, as determined by a survey and documented, are below the limits specified in Table IV-1 prior to applying the covering. A reasonable effort must be made to minimize the contamination prior to use of any covering.
3. The radioactivity on the interior surfaces of pipes, drain lines, or ductwork shall be determined by making measurements at all traps, and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or ductwork. Surfaces of premises, equipment, or scrap which are likely to be contaminated but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement shall be presumed to be contaminated in excess of the limits.
4. Upon request, the Commission may authorize a licensee to relinquish possession or control of premises, equipment, or scrap having surfaces contaminated with material in excess of the limits specified. This may include, but would not be limited to, special circumstances such as razing of buildings, transfer or premises to another organization continuing work with radioactive materials, or conversion of facilities to a long-term storage or standby status. Such request must:

a. Provide detailed, specific information describing the premises, equipment or scrap, radioactive contaminants, and the nature, extent, and degree of residual surface contamination.

b. Provide a detailed health and safety analysis which reflects that the residual amounts of material on surface areas, together with other considerations such as prospective use of the premises, equipment or scrap, are unlikely to result in an unreasonable risk to the health and safety of the public.

5. Prior to release of premises for unrestricted use, the licensee shall make a comprehensive radiation survey which establishes that contamination is within the limits specified in Table IV-1. A copy of the survey report shall be filed with the Division of Fuel Cycle and Material Safety, USNRC, Washington, D.C. 20555, and also with the Director of the Regional Office of the Office of Inspection and Enforcement, USNRC, having jurisdiction. The report should be filed at least 30 days prior to the planned date of abandonment. The survey report shall:

   a. Identify the premises.

   b. Show that reasonable effort has been made to eliminate residual contamination.

   c. Describe the scope of the survey and general procedures followed.

   d. State the findings of the survey in units specified in the instruction.

Following review of the report, the NRC will consider visiting the facilities to confirm the survey.

TABLE IV-1

ACCEPTABLE SURFACE CONTAMINATION LEVELS

NUCLIDES[a]	AVERAGE[b c f]	MAXIMUM[b d f]	REMOVABLE[b e f]
U-nat, U-235, U-238, and associated decay products	5,000 dpm α/100 cm^2	15,000 dpm α/100 cm^2	1,000 dpm α/100 cm^2
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/100 cm^2	300 dpm/100 cm^2	20 dpm/100 cm^2
Th-nat, Th-232, Sr-90 Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000 dpm/100 cm^2	3,000 dpm/100 cm^2	200 dpm/100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except SR-90 and other noted above.	5,000 dpm $\beta\gamma$/100 cm^2	15,000 dpm $\beta\gamma$/100 cm^2	1,000 dpm $\beta\gamma$/100 cm^2

[a] Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

[b] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

[d] The maximum contamination level applies to an area of not more than 100 cm^2.

[e] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

[f] The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

Excerpts from
Proposed
ANSI N328-197

Proposed American National Standard

Control of Radioactive Surface Contamination on Materials, Equipment, and Facilities to be Released for Uncontrolled Use

Secretariat
Health Physics Society

Property shall not be released for uncontrolled use unless documented measurements show the total and removable contamination levels to be no greater than the values in Table IV-2 or Table IV-3. (Table IV-3 is easier to apply when the contaminants cannot be individually identified.)

Where potentially contaminated surfaces are not accessible for measurement (as in some pipes, drains, and ductwork), such property shall not be released pursuant to this standard, but made the subject of case-by-case evaluation. Credit shall not be taken for coatings over contamination.

Table III-2. Surface contamination limits

The levels may be averaged[a] over the 1 m^2 provided the maximum activity in any area of 100 cm^2 is less than 3 times the limit value.

Nuclide	Limit (activity) dpm/100 cm^2	
	Total	Removable
Group 1: Nuclides for which the nonoccupational MPC_a[b] is 2 x 10^{-13} Ci/m^3 or less or for which the nonoccupational MPC_w[c] is 2 x 10^{-7} Ci/m^3 or less; includes Ac-227; Am-241; -242m, -243; Cf-249; -250, -251, -252; Cm-243, -244, -245, -246, -247, -248; I-125, -129; Np-237; Pa-231; Pb-210; Pu-238, -239, -240, -242, -244; Ra-226, -228; Th-228, -238.[d]	100	20
Group 2: Those nuclides not in Group 1 for which the nonoccupational MPC_a[b] is 1 x 10^{-12} Ci/m^3 or less or for which the nonoccupational MPC_w[c] is 1 x 10^{-6} Ci/m^3 or less; includes Es-254; Fm-256; I-126, -131, -133; Po-210; Ra-223; Sr-90; Th-232; U-232.[d]	1000	200
Group 3: Those nuclides not in Group 1 or Group 2.	5000	1000

[a] See note following Table 2 on applications of limits.

[b] MPC_a: Maximum Permissible Concentration in Air applicable to continuous exposure of members of the public as published by or derived from an authoritative source such as NCRP, ICRP, or NRC (10 CFR 20, Appendix B, Table 2, Column 1).

[c] MPC_w: Maximum Permissible Concentration in Water applicable to members of the public.

[d] Values presented here are obtained from 10 CFR Part 20. The most limiting of all given MPC values (e.g., soluble vs. insoluble) are to be used. In the event of the occurrence of a mixture of radionuclides, the fraction contributed by each constituent of its own limit shall be determined and the sum of the fractions must be less than one.

Table IV-3. Alternate surface contamination limits

(All alpha emitters, except U-nat and Th-nat are considered as a group.) The levels may be averaged over 1 m^2[a] provided the maximum activity in any area of 100 cm^2 is less than 3 times the limit value.

Nuclide	Limit (activity) dpm/100 cm^2	
	Total	Removable
If the contaminant cannot be identified; or if alpha emitters other than U-nat and Th-nat are present; or if the beta emitters comprise Ac-227, Ra-226, Ra-228, I-125, and I-129.	100	20
If it is known that all alpha emitters are generated from U-nat and Th-nat; and beta emitters are present which, while not identified, do not include Ac-227, I-125, I-129, Ra-226, and Ra-228.	1000	200
If it is known that alpha emitters are generated only from U-nat and Th-nat; and the beta emitters, while not identified, do not include Ac-227, I-125, I-129, Sr-90, Ra-223, Ra-228, I-126, I-131, and I-133.	5000	1000

[a]Note on application of Tables 1 and 2 to isolated spots or activity:

For purposes of averaging, any m^2 of surface shall be considered to be contaminated above the limit, L, applicable to 100 cm^2 if:

a. From measurements of a representative number, n, of sections, it is determined that $1/n \sum_{\eta} Si \geq L$, where Si is the dpm/100 cm^2 determined from measurement of section i; or

b. On surfaces less than 1 m^2, it is determined that $1/n \sum_{\eta} Si \geq AL$, where A is the area of the surface in units of m^2; or

c. It is determined that the activity of all isolated spots or particles in any area less than 100 cm^2 exceeds 3L.

SURGEON GENERAL'S GUIDELINES
Part 712
Grand Junction Remedial Action Criteria

Federal Register, Vol. 41, No. 253, pp. 56777-8, Thursday, December 30, 1976

PART 712 - GRAND JUNCTION REMEDIAL ACTION CRITERIA

712.1 Purpose

(a) The regulations in this part establish the criteria for determination by ERDA of the need for, priority of and selection of appropriate remedial action to limit the exposure of individuals in the area of Grand Junction, Colo., to radiation emanating from uranium mill tailings which have been used as construction-related material.

(b) The regulations in this part are issued pursuant to Publ. L. 92-314 (86 Stat. 222) of June 16, 1972.

712.2 Scope

The regulations in this part apply to all structures in the area of Grand Junction, Colo., under or adjacent to which uranium mill tailings have been used as a construction-related material between January 1, 1951, and June 16, 1972, inclusive.

712.3 Definitions

As used in this part:

(a) "Administrator" means the Administrator of the Energy Research and Development Administration or his duly authorized representative.

(b) "Area of Grand Junction, Colo.," means Mesa County, Colo.

(c) "Background" means radiation arising from cosmic rays and radioactive material other than uranium mill tailings.

(d) "ERDA" means the Energy Research and Development Administration or duly authorized representative thereof.

(e) "Construction-related material" means any material used in the construction of a structure.

(f) "External gamma radiation level" means the average gamma radiation exposure rate for the habitable area of a structure as measured near floor level.

(g) "Indoor radon daughter concentration level" means that concentration of radon daughters determined by: (1) averaging the results of 6 air samples, each of at least 100 hours duration, and taken at a minimum of 4-week intervals throughout the year in a habitable area of a structure, or (2) utilizing some other procedure approved by the Commission.

(h) "Milliroentgen (mR) means a unit equal to one-thousandth (1/1000) of a roentgen which roentgen is defined as an exposure dose of X or gamma radiation such that the associated corpuscular emission per 0.001293 gram of air produces, in air, ions carrying one electrostatic unit of quantity of electricity of either sign.

(i) "Radiation" means the electromagnetic energy (gamma) and the particulate radiation (alpha and beta) which emanate from the radioactive decay of radium and its daughter products.

(j) "Radon daughters" means the consecutive decay products of radon-222. Generally these include Radium A (polonium-218), Radium B (lead-218), Radium C (bismuth-214), and Radium C′ (polonium-214).

(k) "Remedial action" means any action taken with a reasonable expectation of reducing the radiation exposure resulting from uranium mill tailings which have been used as construction-related material in and around structures in the area of Grand Junction, Colo.

(l) "Surgeon General's guidelines" means radiation guidelines related to uranium mill tailings prepared and released by the Office of the U.S. Surgeon General, Department of Health, Education and Welfare on July 27, 1970.

(m) "Uranium mill tailings" means tailings from a uranium mill operation involved in the federal uranium procurement program.

(n) "Working Level" (WL) means any combination of short-lived radon daughter products in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

712.4 Interpretations

Except as specifically authorized by the Administrator [illegible] no interpretation of the meaning of the regulations in this [illegible] officer or employee of ERDA other than a written interpretation [illegible] General Counsel will be recognized to be binding upon ERDA.

712.5 Communications

Except where otherwise specified in this part, all communications [illegible] concerning the regulations in this part should be addressed [illegible] Director, Division of Safety, Standards, and Compliance, U.S. [illegible] Research and Development Administration, Washington, D.C. [illegible]

712.6 General radiation exposure level criteria for remedial [illegible]

The basis for undertaking remedial action shall be the [illegible] guidelines published by the Surgeon General of the United States [illegible] guidelines recommend the following graded action levels for [illegible] action in terms of external gamma radiation level (EGR) and [illegible] daughter concentration level (RDC) above background found with [illegible] constructed on or with uranium mill tailings:

EGR	RDC	Recommended [illegible]
Greater than 0.1 mR/hr	Greater than 0.05 WL	Remedial action [illegible]
From 0.05 to 0.1 mR/hr	From 0.01 to 0.05 WL	Remedial action [illegible] suggested
Less than 0.05 mR/hr	Less than 0.01 WL	No remedial action indicated

712.7 Criteria for determination of possible need for remedial [illegible]

Once it is determined that a possible need for remedial [illegible] exists, the record owner of a structure shall be notified of the structure's eligibility for an engineering assessment to confirm [illegible] need for remedial action and to ascertain the most appropriate [illegible]

measure, if any. A determination of possible need will be made if as a result of the presence of uranium mill tailings under or adjacent to the structure, one of the following criteria is met:

(a) Where ERDA approved data on indoor radon daughter concentration levels are available:

(1) For dwellings and schoolrooms: An indoor radon daughter concentration level of 0.01 WL or greater above background.

(2) For other structures: An indoor radon daughter concentration level of 0.03 WL or greater above background.

(b) Where ERDA approved data on indoor radon daughter concentration levels are not available:

(1) For dwellings and schoolrooms:

(i) An external gamma radiation level of 0.05 mR/hr or greater above background.

(ii) An indoor radon daughter concentration level of 0.01 WL or greater above background (presumed).

(A) It may be presumed that if the external gamma radiation level is equal to or exceeds 0.02 mR/hr above background, the indoor radon daughter concentration level equals or exceeds 0.01 WL above background.

(B) It should be presumed that if the external gamma radiation level is less than 0.001 mR/hr above background, the indoor radon daughter concentration level is less than 0.01 WL above background and no possible need for remedial action exists.

(C) If the external gamma radiation level is equal to or greater than 0.001 mR/hr above background but is less than 0.02 mR/hr above background, measurements will be required to ascertain the indoor radon daughter concentration level.

(2) For other structures:

(i) An external gamma radiation level of 0.15 mR/hr above background averaged on a room-by-room basis.

(ii) No presumptions shall be made on the external gamma radiation level/indoor radon daughter concentration level relationship. Decisions will be made in individual cases based upon the results of actual measurements.

712.8 Determination of possible need for remedial action where criteria have not been met

The possible need for remedial action may be determined where the criteria in 712.7 have not been met if various other factors are present. Such factors include, but are not necessarily limited to, size of the affected area, distribution of radiation levels in the affected area, amount of tailings, age of individuals occupying affected area, occupancy time, and use of the affected area.

712.9 Factors to be considered in determination of order or priority for remedial action

In determining the order or priority for execution of remedial action, consideration shall be given, but not necessarily limited to, the following factors:

(a) Classification of structure. Dwellings and schools shall be considered first.

(b) Availability of data. Those structures for which data on indoor radon daughter concentration levels and/or external gamma radiation levels are available when the program starts and which meet the criteria in 712.7 will be considered first.

(c) Order of application. Insofar as feasible remedial action will be taken in the order which the application is received.

(d) Magnitude of radiation level. In general, those structures with the highest radiation levels will be given primary consideration.

(e) Geographical location of structures. A group of structures located in the same immediate geographical vicinity may be given priority consideration particularly where they involve similar remedial efforts.

(f) Availability of structures. An attempt will be made to schedule remedial action during those periods when remedial action can be taken with minimum interference.

(g) Climatic conditions. Climatic conditions or other seasonable considerations may affect the scheduling of certain remedial measures.

712.10 Selection of appropriate remedial action

(a) Tailings will be removed from those structures where the appropriately averaged external gamma radiation level is equal to or greater than 0.05 mR/hr above background in the case of dwellings and schools and 0.15 mR/hr above background in the case of other structures.

(b) Where the criterion in paragraph (a) of this section is not met, other remedial action techniques, including but not limited to sealants, ventilation, and shielding, may be considered in addition to that of tailings removal. ERDA shall select the remedial action technique or combination of techniques, which it determined to be the most appropriate under the circumstances.

ENVIRONMENTAL PROTECTION AGENCY
Title 40, Part 141

Drinking Water Regulations--Radionuclides

Interim Primary Drinking Water Regulations
Promulgation of Regulations on Radionuclides
Federal Register, Vol. 41, No. 133, pp. 28402-9, Friday, July 9, 1976

Part 141.15 Federal Register
Vol. 41, No. 133, p. 28404, Friday, July 9, 1976

Maximum contamination levels for ^{226}Ra, ^{228}Ra, and gross alpha particle radioactivity.

(a) Combined ^{226}Ra and ^{228}Ra - 5 pCi/liter.

(b) Gross alpha particle activity (including ^{226}Ra but excluding radon and uranium) - 15 pCi/liter.

APPENDIX V

EVALUATION OF RADIATION EXPOSURE AT THE FORMER SIMONDS SAW AND STEEL COMPANY (CURRENT NAME - GUTERL SPECIAL STEEL CORPORATION) LOCKPORT, NEW YORK

The U.S. Department of Energy (DOE) has determined that portions of the former Simonds Saw and Steel Company in Lockport, New York, are presently contaminated with radioactive residues from previous uses of this property. Under current conditions of use, this contamination does not cause employees working at the site to receive radiation exposures appreciably different from those due to naturally occurring environmental radioactivity. However, under different conditions of use (i.e., use of the contaminated soils for growing crops, actions which involve agitation or abrasion of dry contaminated surfaces, or extended maintenance activities involving contaminated portions of existing property and equipment), there could be a potential for radiation exposure to people. For that reason, the DOE will conduct further evaluations to enable appropriate actions to be identified that will preclude any concerns for radioactivity at this site.

The Simonds Company performed rolling mill operations on uranium metal (and, to a much smaller extent, thorium metal) during the period 1948 to 1956. These operations were performed in two buildings on the site, designated as Buildings A and B. Building A is presently used for rolling mill operations on nonradioactive metals. That portion of Building B which was used for uranium and thorium operations is now used as a cleaning area for descaling metal sheets and bars. Approximately 50 persons work in these two buildings and approximately 450 persons work at the entire facility, now known as Guterl Special Steel Corporation.

Uranium and thorium operations at this facility were performed under two separate contracts. The first contract, in effect until 1952, was negotiated with the New York Operations Office of the Atomic Energy Commission (AEC). The second contract was a subcontract with National Lead of Ohio, which was under contact to the AEC to provide feed material to the Hanford facility in Richland, Washington. More than 99 percent of the work done under these two contracts involved uranium which was rolled on the 16-inch rolling mill located in Building A. A small amount of material was rolled in Building B. Radiological monitoring and safety during all operations was the responsibility of the AEC. Results of a survey conducted in November 1958, indicated that radiation levels were highest in the quench tank area of Building A. The tank was

removed and clean steel plates placed over the area. Other areas showing elevated radiation levels were scrubbed and vacuumed. A second radiation survey was performed in December 1958 to verify decontamination.

Most of the contamination at the Lockport site is due to natural uranium. Employees at this site receive slight radiation exposures from this contamination. Exposures come from beta and gamma radiations emitted by contamination on surfaces of equipment or in the ground. Additional exposures received by ingestion (i.e., eating or drinking in one of the contaminated areas) are relatively small compared with direct beta and gamma radiation. At present, exposures received by inhalation--that is, by breathing air contaminated with radioactive materials--are also small compared with direct beta and gamma radiation. A summary of radiation exposures at the Lockport site is provided in Table V-1 along with appropriate guidelines and generally accepted background values.

The naturally occurring radionuclides present at this site are also present in minute quantities throughout our environment. Concentrations of these radionuclides in normal soils, air, water, food, etc., are referred to as background concentrations. Radiation exposures resulting from this environmental radioactivity are referred to as background exposures. These background exposures are not caused by any human activity and, to a large extent, can be controlled only through man's moving to areas with lower background exposures. Each and every human receives some background exposure daily.

The use of radioactive materials for scientific, industrial, or medical purposes may cause radiation exposures above the background level to be received by workers in the industry and, to a lesser extent, by members of the general public. Scientifically based guidelines have been developed to place an upper limit on these additional exposures. Limits established for exposures to the general public are much lower than the limits established for workers in the nuclear industry.

Uranium-238 is believed to have been created when the earth was formed. It is still present today because it takes a very long time to decay. The half life is a measure of the time required for radioactive decay; for uranium-238 it is 4.5 billion years. For example, consider

an initial inventory of one curie* of uranium-238. One-half curie will remain in existence at the end of 4.5 billion years, with one-quarter curie surviving to 9 billion years. As the uranium-238 decays, it changes into another substance--thorium-234. Thorium-234 is called the "daughter" of uranium-238. In turn, thorium-234 is the "parent" of protactinium-234. Radioactive decay started by uranium-238 continues as shown in Table V-2 until stable lead is formed. The "decay product" listed in Table V-2 is the radiation produced as the parent decays.

Direct Beta and Gamma Radiation Exposures

As may be seen in Table V-2, uranium-238 decays into thorium-234 which decays into protactinium-234. The half lives of these latter two radionuclides are very short compared with uranium-238. Consequently, the concentrations of these two radionuclides are today the same as the concentration of uranium-238. Thorium-234 and protactinium-234 emit beta and gamma radiation. Hence, surfaces contaminated with uranium-238 two decades ago can now produce beta- and gamma-radiation exposures.

Surfaces in Building A are contaminated with uranium-238. The Nuclear Regulatory Commission (NRC) requirements applicable to its licensees state that the average beta and gamma exposure rate measured at a distance of 1 centimeter above surfaces should not exceed 0.2 millirad† per hour; individual readings should not exceed 1.0 millirad per hour. Readings taken in the area of the rolling mill and around the quench tank exceed the NRC guidelines for both maximum and average exposure rates. Exposure measurements made on the rolling mill ranged up to 3.5 millirad per hour. The highest readings were obtained under a floor plate in the area of the quench tank, where the

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*A curie is a unit defined for expressing the amount of radioactivity present in a substance; one curie represents 37 billion radioactive disintegrations per second.

†The millirad is a unit used to measure the amount of radiation energy absorbed by human tissue.

exposure rates ranged up to 42 millirad per hour. A soil sample taken at this location contained approximately 21,000 picocuries* of uranium-234 per gram of soil.

For comparison, the skin dose which would be expected from a normal year's watching of color television by an adult is 1.6 millirads; for a child less than 15 years of age, the comparable dose is 3.6 millirads per year (according to the United Nations Scientific Committee on the Effects of Atomic Radiation).

The primary concern of the NRC guideline is exposure of skin surfaces. The thickness of ordinary shoe soles is adequate to protect the skin of feet from beta radiation. Other areas of body skin are adequately protected from these exposures if they remain away from these surfaces. In most cases, exposures are negligible at a distance of 1 foot away from these surfaces. Although potential exists for exposures far in excess of the guidelines, beta and gamma surface exposures are believed to be inconsequential to employees at this site due to the relative inaccessibility of contaminated surfaces during normal work functions.

It is also seen in Table V-2 that several of the daughters of uranium-238 emit gamma radiation (gamma rays are penetrating radiation like X-rays). Hence, the contamination on this site is a potential source of external gamma radiation exposure. External gamma exposures measured at 1 meter above the ground or floor of buildings ranged from 5 to 48 microRoentgens† per hour. Exposure to this upper level for 2000 hours per year, a typical work year, would lead to a maximum exposure of 96,000 microRoentgens. For comparison, a typical chest X-ray (according to Department of Health, Education, and Welfare data) might yield an exposure of 27,000 microRoentgens. Background levels (to which persons are exposed on a continuous basis) in the Lockport area averaged 8 microRoentgens per hour. This results in an annual exposure of 70,000 microRoentgens.

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*One picocurie is one million-millionth of a curie, previously defined.

†The Roentgen is a unit which is defined for radiation protection purposes for people exposed to penetrating gamma radiation. A micro-Roentgen is one-millionth of a Roentgen.

The National Council on Radiation Protection and Measurement (NCRP) has recommended a maximum annual whole-body exposure rate of 500,000 microRoentgens per year to an individual continually exposed in the general public. This value corresponds to 250 microRoentgens per hour for 2000 exposure hours (40 hours per week and 50 weeks per year). Thus, all whole-body gamma radiation exposures at this site are well within guideline values.

Other Considerations of Exposure

Radon-222, one of the members of the uranium-238 family shown in Table V-2, is an inert gas which may leave the soil and enter the atmosphere. Measurements taken at the site indicate that radon-222 concentrations are less than 0.4 picocuries per liter. These concentrations cannot be distinguished from normal background concentrations. Thus, all exposures to radon-222 at the former Simonds facility are below the concentration guideline for the general public given in 10 CFR 20.* Furthermore, these exposures to radon-222 cannot be distinguished from normal background exposures.

Radioactive decay of radon-222 is rapid (days) and its decay gives rise to short-lived daughters as shown in Table V-2. Background concentrations of radon daughters both inside and outside structures are typically less than 0.01 working level (WL).† All radon daughter concentrations measured in buildings at the Lockport site were far below the guide value of 0.03 WL given in Federal Regulation 10 CFR 712.‡

Health studies of uranium and other hard-rock miners have established that inhalation of large quantities of daughters of radon-222

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*Title 10 Code of Federal Regulations Part 20 is a regulatory document published by the Nuclear Regulatory Commission and may be found in the Federal Register.

†The working level is a unit which was defined for radiation protection purposes for uranium miners. It represents a specific level of energy emitted by the short-lived daughters of radon.

‡Title 10 Code of Federal Regulations Part 712 is a document published by the Energy Research and Development Administration (now Department of Energy) and may be found in the Federal Register.

over long periods of time increases an individual's risk of contracting lung cancer. The present federal guide value for uranium mine workers (given by the Environmental Protection Agency [EPA]), when translated to the units discussed here, would limit mine workers to an exposure of 0.33 working level, assuming exposure for 2000 hours per year, a typical work year. This level is significantly lower than the exposures received by most of the miners included in the health studies referred to above.

Water samples taken at the site show little evidence of contamination by radionuclides. The concentration of each radionuclide was at least ten times lower than the maximum permissible concentration in water (MPC_w) as set forth in 10 CFR 20 for members of the general public.

Use of the contaminated soil for growing crops could produce additional human exposures through consumption of these crops. Actions which involve agitation or abrasion of dry, contaminated surfaces could create airborne radioactive dust which, when inhaled, would produce internal human exposures.

Risk and Radiation Exposures

Risks resulting from radiation exposures should be considered within the context of other risks incurred in normal living. For simplicity, risks to health may be classified in four categories:

1. Unacceptable--problems with risk so high as to require immediate action, such as severe diseases where medical treatment is required to save a life.
2. Concerned--problems where people are willing to spend time and money to reduce potential hazards. Examples of this include the maintenance of public highways and signs, signals, fire departments, and rescue squads.
3. Recognized--problems where people may accept some inconvenience to avoid certain activities such as flying in airplanes, swimming alone, etc.
4. No great concern--problems with a low frequency of occurrence. There is an awareness of potential hazard, but an accompanying feeling that these problems occur only to other people.

An individual may be exposed to risks over which he can exercise some control (voluntary), and risks over which he feels he has no personal control or choice (involuntary).

Daily, an individual is confronted with decisions about risk which have an associated benefit--for example, driving a car. This can serve as an illustration that a voluntary, concerned risk may be deemed appropriate due to the desirable perceived benefit. As another example, an individual who smokes cigarettes has subjected himself to a risk of lung cancer which is about ten times higher than that for a nonsmoker.

For purposes of radiation protection, all radiation exposures are assumed to be capable of increasing an individual's risk of cancer death. A precise numerical value cannot be assigned with any certainty to a given individual's increase in risk attributable to radiation exposure. The reasons for this are numerous; they include the individual's age at onset of exposure, variability in latency period (time between exposure and physical evidence of disease), the individual's personal habits and state of health, previous or concurrent exposure to other cancer-causing agents, and the individual's family medical history. Because of these variables, large uncertainties would exist in any estimates of the number of increased cancers in the relatively small working population at the Lockport site.

The normal annual death rate from lung cancer for all population groups in Niagara County (as of 1970) was 25.4 deaths per 100,000 population.* At the same time, the annual death rates from lung cancer for all population groups in the United States and the state of New York were 21.1 and 24.2 deaths per 100,000 population, respectively. A one-year exposure to the guideline value for uranium miners (0.33 working level for 2000 hr) might increase the risk of death due to lung cancer by approximately four percent.

The annual death rate from all types of cancer among all population groups in Niagara County (as of 1970) was 159 deaths per 100,000

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*Mortality statistics were obtained from data in *U.S. Cancer Mortality by County: 1950-1969*, prepared by the National Cancer Institute, 1973, available from the U.S. Government Printing Office.

population. At the same time, the death rates from all types of cancer for all population groups in the United States and in the state of New York were 151 and 172 per 100,000 population, respectively. A one-year exposure to penetrating gamma radiation of 500,000 microRoentgens might increase the risk of death due to all types of cancer by about one-tenth of a percent. Exposures in excess of these guideline values would be expected to result in proportionately higher increases in risk. Consequently, any action taken to reduce either the rate or the duration of radiation exposure would also reduce the risk attendant to that exposure.

There are no data at present which give evidence of a relationship between low-level exposure of the skin and the development of skin cancers. This does not mean that skin cancer cannot be produced by low-level exposures. This does mean that the risk associated with guideline level exposures of the skin is so small that it cannot be quantified.

Remedial Measures

Employees working in Building A at the Lockport site are currently receiving small radiation exposures to the skin. The risk associated with these exposures is imperceptibly small. However, the potential exists for more serious exposures by inhalation of radioactive dusts. Decontamination of the uranium-238 residues on surfaces on and near the 16-inch rolling mill would remove the source of actual and potential exposures associated with Building A. The next stage of the Department of Energy's Remedial Action Program is to identify and evaluate various alternatives to assure adequate protection against current and potential radiation exposures at this location.

Summary

In summary, the Lockport site is contaminated with residues containing natural uranium. Under current conditions of site use, this contamination does not cause employees working at the site to receive radiation exposures appreciably different from those due to background radiation. However, under different conditions of use (i.e., use of

contaminated soils for growing crops or actions which involve agitation or abrasion of dry contaminated surfaces), potential radiation exposures to employees and the public could result. For that reason, the DOE will conduct further evaluations to enable the identification of appropriate actions which will preclude any concerns for radioactivity at this site.

Table V-1. Summary of exposure data at the former Simonds Saw and Steel Company, Lockport, New York

Exposure source	Background levels	Guideline value for general public	Guideline value for radiation workers	Average levels at Simonds site
Radon in air	Less than one picocurie[a] per liter of air	Continuous exposure to 3 picocuries per liter of air	Exposure for 40 hours per week and 50 weeks per year to 30 picocuries per liter of air	Maximum concentration of 0.04 picocurie per liter of air
Radon daughters in air	Less than 0.01 working level[b]	0.01 working level for residences and school rooms, and 0.03 working level for other structures	0.33 working level for uranium miners exposed for 40 hours per week and 50 weeks per year	Less than 0.001 working level
Gamma radiation from daughters of radium and uranium	8 micro-Roentgens[c] per hour in the Lockport area	250 microRoentgens per hour above natural background for 40 hours per week and 50 weeks per year for an individual in the public. This is equivalent to 0.5 Roentgen per year	2500 microRoentgens per hour for 40 hours per week and 50 weeks per year. This is equivalent to 5 Roentgens per year	Average in Buildings A and B was 12 micro-Roentgens per hour. Maximum reading of 48 microRoentgens per hour near the 16-inch rolling mill and the furnace area

[a]The picocurie is a unit which was defined for expressing the amount of radioactivity present in a substance.

[b]The working level is a unit which was defined for radiation protection purposes for uranium miners. It represents a specific level of energy emitted by the short-lived daughters of radon.

[c]The Roentgen is a unit which was defined for radiation protection purposes for people exposed to penetrating gamma radiation. A microRoentgen is one-millionth of a Roentgen.

Table V-2. Uranium-238 decay series

Parent	Half-life	Decay products	Daughter
uranium-238	4.5 billion years	alpha	thorium-234
thorium-234	24 days	beta, gamma	protactinium-234
protactinium-234	1.2 minutes	beta, gamma	uranium-234
uranium-234	250 thousand years	alpha	thorium-230
thorium-230	80 thousand years	alpha	radium-226
radium-226	1600 years	alpha	radon-222
radon-222	3.8 days	alpha	polonium-218
polonium-218[a]	3 minutes	alpha	lead-214
lead-214[a]	27 minutes	beta, gamma	bismuth-214
bismuth-214[a]	20 minutes	beta, gamma	polonium-214
polonium-214[a]	$\frac{2}{10,000}$ second	alpha	lead-210
lead-210	22 years	beta	bismuth-210
bismuth-210	5 days	beta	polonium-210
polonium-210	140 days	alpha	lead-206
lead-206	stable	none	none

[a]Short-lived radon daughters.

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